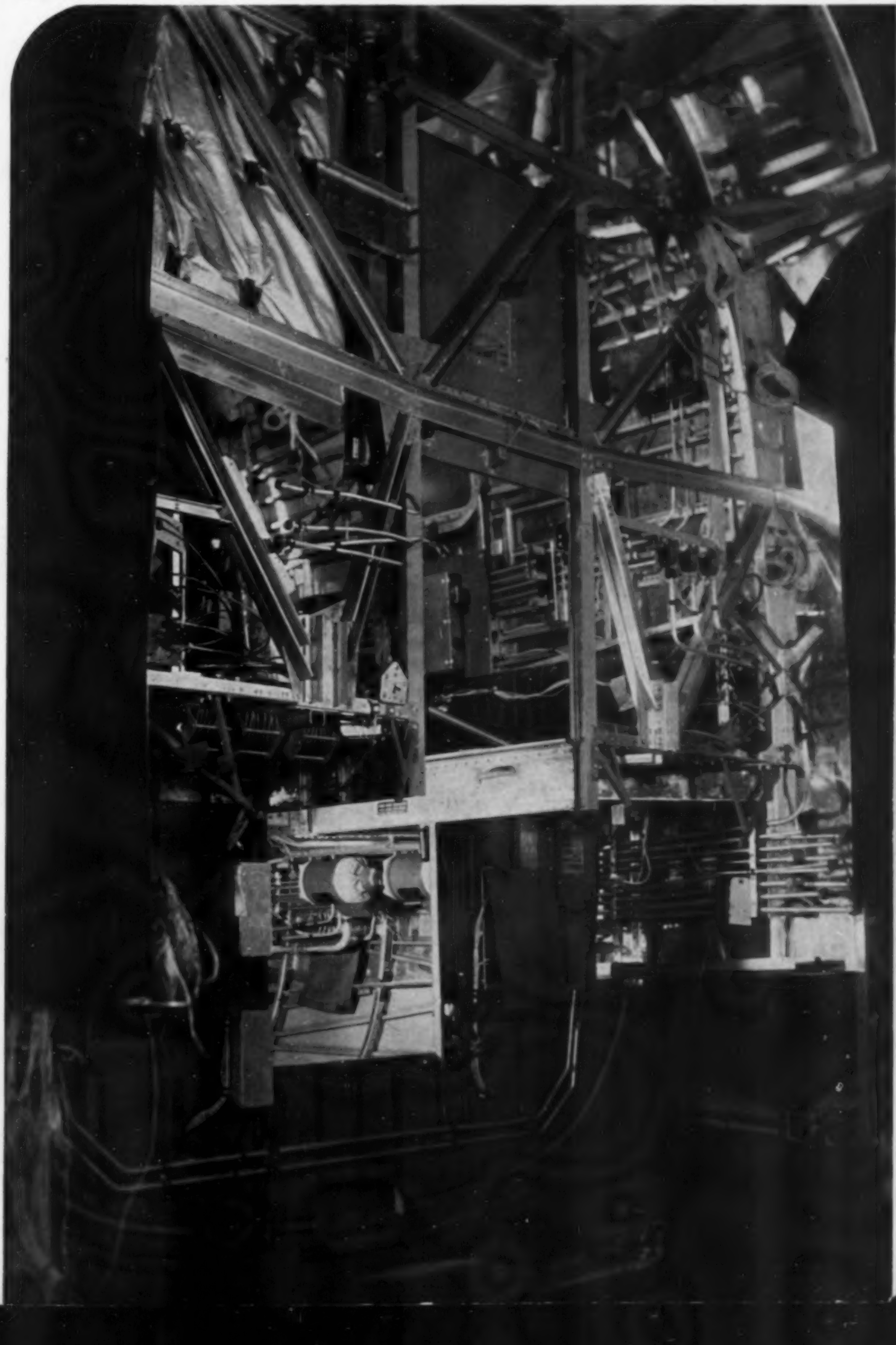
MAY, 1944



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METAL PROGRESS

Vol. 45 *May, 1944* *No. 5*

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The kodachrome from which the front cover was made was loaned by the editor of *Plane Talk*, house organ of Consolidated Vultee Aircraft Corp., and shows the control cables, instruments, wiring and conduit in the nose section of a large aircraft

Unfortunately cartridge brass is high enough in zinc to be among the alloys susceptible to stress corrosion, long termed "season cracking" in the brass industry. To avoid it in ammunition, residual internal stress must be held below a certain value

"Season Cracking" in Cartridge Brass

IN CONTINUING THE DISCUSSIONS on cartridge brass and its properties, it is logical to include season cracking, so-called, because of the close association of this phenomenon with the manufacturing and testing of cartridge cases. At the outset, however, it should be recognized that "season cracking" is only a name peculiar to the brass industry — a part of brass's jargon, so to speak — and that stress corrosion is the proper name of what we are talking about. It is encountered in copper alloys other than brasses, as well as certain types of steels, and in aluminum and magnesium. In fact something that was known to give trouble to cold worked brasses many years ago, and for which various remarkable "cures" were touted, has now been found to cause trouble in a wide variety of industrial alloys. The viewpoint in this article will therefore not be confined to cartridge brass alone.

Further, the approach to the problem recognizes that the requirements of war materials, in respect to freedom from susceptibility to season cracking, are different and far more rigid than for peace-time manufacture. There can be no quarrel with the war-time standard that failure cannot be tolerated, for many and obvious reasons. In peace-time, however, *economic* life is very definitely a factor which alters the viewpoint toward the absolute necessity for eliminating susceptibility to failure, and makes less strict the interpretation of the usual tests.

The failure we are now talking about is most often seen as a ragged crack, or cracks — which will be parallel to the long axis of drawn cups or tubes, for example. It may appear in perfectly sound material after a few days, or weeks — or years, even. Inexperienced observers may frequently be baffled by the apparent lack of any observable cause, especially since stress may be thought to be absent.

Three factors are necessary to produce such failures: Chemical composition, stress, and corrosion.

In reference to chemical composition — certain of the copper or copper-base alloys are, practically speaking, free from susceptibility to stress corrosion; for example, commercial coppers such as electrolytic (tough pitch), deoxidized, silver bearing, arsenical and oxygen-free copper. Among the brasses are those compositions containing up to 15% zinc (see Fig. 3 in *Metal Progress* for June 1943, page 900, for commercial designations); the phosphor bronzes (copper-tin) and cupro-nickel (commonly containing 20% and 30% nickel) are also immune. For brasses, the borderline of non-susceptibility to susceptibility is at about 20% zinc. 85-15 red brass has been known to crack when in the form of hard drawn, large diameter, heavy walled tubes. As zinc increases to its commercial maximum, susceptibility to season cracking also increases. Other copper alloys also susceptible are: Naval brass,

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admiralty, aluminum brass, silicon bronze (Grade A), manganese bronze and certain types of aluminum bronze.

Any user of these alloys would naturally like to know with certainty just what conditions will produce failure and how long it will take. Neither question can be answered with precision. They *can* be answered by general rules and good judgment. Obviously, if a choice of alloy is possible, using one not susceptible is the simplest way to avoid it, but economic, fabricating or mechanical factors may prevent. Practically speaking, therefore, the answer lies in *(a)* avoiding stress in the first place, *(b)* treating to remove stress or *(c)* eliminating or reducing corrosion. Since *both* stress and corrosion are required, elimination of one of them removes the cracking tendency.

Stress may be internal (within the metal, resulting from cold deformation) or external (from an applied load). The cold drawing of strip into cups, severe or multi-directional bending, tube and rod drawing, and stamping of irregular shapes are examples of cold deformations producing internal stress.

Threshold Stress Must Be Exceeded

It should be made clear, however, that internal stress is not necessarily responsible for cracking. Theoretically and practically it would be rather difficult to insure that any piece of metal is entirely stress free. What is responsible is a residual stress in excess of a certain threshold value.* It may therefore be convenient in analyzing season cracking tendencies of a given part to think of the operations required to produce it, and whether a differential in stress will exist between one portion and another — at the same time considering that this differential will tend to exist if one portion is cold worked or deformed more than another. This condition is frequent because *(a)* a given shape can only be made by deforming in certain areas, *(b)* cross sections may be too heavy for the equipment to work them uniformly in all parts and *(c)* physical properties induced, within certain limits, by cold working may be necessary.

However, as would be suspected from the foregoing, there is a maximum tendency toward cracking due to internal stress. If a curve is superimposed upon Fig. 4, 6 or 8 (*Metal Progress*, June and August, 1943), which is roughly dome-shaped with a maximum at 20% cold work, it would represent this *tendency* to season crack. In other words, light reductions produce greater tendency to cracking than heavy, due to the non-uniformity of the work and a consequent higher stress differential. At the same time it is obvious that cold reductions of 80%, say, produce such thorough cold working that differences are relatively small and cracking tendency may be *nil.*

Other than controlling the amount of reductions to decrease cracking tendency, control of grain size is another means. Small grained material has less tendency to crack than large grained, whether cold worked or annealed and stressed. In other words, small grain size decreases cracking tendency due either to internal or external stress. However, fabricating or other considerations may prevent the effective use of this factor; for example, large grain sizes are required for cartridge case disks in order that they may be cupped successfully.

External stress also causes cracking and a threshold value for this stress exists below which cracking will not occur. Since such stress may be indeterminate in typical uses, the only practical manner of avoiding cracking is to use alloys with low susceptibility, *or* avoid unduly high stress. For a great number of industrial applications the limiting stress allowable for mechanical or design reasons will be within safe limits, unless corroding conditions exist among the severe types to be mentioned later.

Practical Methods for Stress Relief

Turning from causes to cures, let's look into the methods by which a fabricated part can be made non-susceptible to stress corrosion cracking. If what we have already said is true, it follows that when the stresses are removed or reduced below the threshold value by stress-relief annealing or by "springing", then the danger is removed. Most widely used and most readily applied to a variety of parts is exposure to heat at time and temperature sufficient to remove the stresses, *but not to soften appreciably.*

(By definition this operation is not true stress relief annealing if there is a ponderable change in physical properties in the direction of lowered strength and hardness and increased ductility. On the contrary, an examination of many sets of data on the low temperature annealing of many coppers and copper-base alloys within the range of 300 to 700° F. shows that a slight increase in hardness and strength will occur at some optimum combination of time and temperature. Heating a sample of silver bearing copper to 600° F. for 30 min. has been known to

*In the presence of mercury, cartridge brass has a threshold value of about 15,000 psi., according to Croft and Sachs.

increase Rockwell B hardness by as much as 6 points. Similarly the effect appears most strongly after heating Type A silicon bronze — 3% silicon — at 550° F. for 35 min., as tensile strength may increase as much as 10,000 psi.)

Generally the stress relief annealing temperatures are between 400 and 700° F. — time being as much as a couple of hours or more at 400° F. and as little as 10 min. at temperature for 700° F. As explained in the article in August 1943 *Metal Progress,* time and temperature factors must be worked out for each individual furnace and part, and stress relief is no exception. If the temperature is too high or the time too long, Rockwell hardness will drop; a maximum of 5 points could be used as a rough-and-ready limit. On the other hand, the mercurous nitrate test will show whether cracking tendency is still present and, if so, then time or temperature should be increased.

Going to the other extreme of heat treatment it is obvious that recrystallized material is not subject to cracking from internal stress. Unfortunately the physical properties may then be insufficient for the designed use.

"Springing" is the term used to describe the relief of stresses in rods, tubes or other similar uniformly shaped lengths, by passing them through multi-rolled straightening machines. These straighteners are built analogous to the roller straighteners familiar to the users of sheet metal, with a large number of small rolls arranged in two horizontal rows but with centers offset from each other. Rolls are then raised or lowered the correct distance apart so that the rod going between them is seriously deformed — appearing like a wriggling snake — the last pairs of rolls restoring the rod to straightness. The action is one of deforming beyond the elastic limit in one direction and then in another. The net permanent deformation is zero, since the rod is delivered straight. The efficiency of this method is recognized in the A.S.T.M. Specification for Naval Brass, B21-42T, which says, "Bars that have been properly straightened or sprung will have internal stresses so broken up as not to be in danger of splitting or cracking. . . ."

The method, however, is most applicable to standard mill shapes and is described here because of the need of understanding that a stress relief anneal, as such, is not necessary with some products.

Table V — Effect of Amines on Cracking of 70-30 Brass

Amine	Number of Specimens Cracked*		Number Days Before Cracking	
	Group A	Group B	Group A	Group B
Methylamine	3	3	4	4
Methylamine (retest)	3	3	1	1
Dimethylamine	0	1	R	45T
Trimethylamine	3	3	45T	45T
Ethylamine	3	3	3	3
Ethylamine (retest)	3	3	2	2
Diethylamine	0	0	R	R
Triethylamine	0	0	R	R
Aniline (Phenylamine)†	—	1	—	12
Aniline†	3	1	45T	45T
Diphenylamine†	—	1	—	1
Diphenylamine†	0	1	R	17
Diphenylamine (retest)†	0	0	S	S
Triphenylamine†	0	1	R	45T
Pyridine	0	0	S	S
Ethanolamine†	3	3	4	4
Ethanolamine (retest)†	—	2	—	3
Ethanolamine†	3	1	4	4
Diethanolamine†	—	1	—	8
Diethanolamine†	—	1	—	10
Diethanolamine†	0	1	R	11
Triethanolamine†	—	1	—	1
Triethanolamine†	2	1	45T	17

*3 samples in each group, unannealed 70-30 brass cups, highly stressed since they cracked in 1 min. in mercurous nitrate.

†Tested at 200° F.; the other runs were made at 100° F.

R — Discontinued tests after 45 days.

S — Discontinued tests after 35 days.

T — Cracks found after pickling off corrosion product.

Corrosion Is Also Necessary

The last factor affecting season cracking, corrosion, is the most variable and the least possible to evaluate under many conditions. There are, however, some very definite conditions of corrosion which are practically certain to cause cracking if any susceptibility at all exists. Ammonia is regarded as the most common and powerful in its ability to cause failure. Mercury and mercury compounds are likewise rapid and severe in their action.* Sulphur dioxide in the presence of water vapor and dilute sulphuric acid films are also responsible for trouble. In addition, certain molten metals such as tin and lead can be destructive, either alone or in combination as solders. Cracking occurring in outdoor atmospheres is generally

*In addition, it should be noted that ammonia and mercury with their compounds are corrosive to copper and copper-base alloys. Equipment for handling these materials should be free from the metals under discussion.

Fig. 22—Typical Season Crack in Cartridge Brass, at 75 Diameters. Note the inter-crystalline nature and lack of deformation of grains alongside fissure*

attributed to the presence of small amounts of ammonia, or sometimes sulphur dioxide. Ammonia or ammoniacal compounds in certain plastics have also been found to be responsible.

Recently tests made at Frankford Arsenal by Rosenthal and Jamieson have shown that certain amines cause cracking in the presence of moist air. The primary amines are more active in this respect than the secondary or tertiary types (see Table V*, page 883).

The speed of a typical chemical reaction is dependent upon the concentration of the reagents and their temperature. Stress corrosion cracking is no exception in that the time elapsing before failure occurs not only depends upon the corrodent but its concentration and temperature. As a consequence, the evaluation of expected service life, if susceptibility to cracking exists, is no more definite than the knowledge of the corroding conditions. The "standard" test for cracking tendency is an example of a severe condition wherein the corrodent is powerful in its action and failure can occur quickly. Exposure to strong ammonia fumes is another potent test. Cracking during soldering operations is a third. On the other hand, a chromium plated brass part on your automobile might have cracked under the foregoing test conditions, but in normal outdoor atmospheres will never crack, even though you run the car as long as you're afraid you will have to.

Consequently, for conditions not readily determined as severe, the expected *time for failure* of a given article cannot be judged without some "measure of susceptibility" such as the mercurous nitrate test, coupled with a goodly amount of experience and judgment in its interpretation.

In this connection, the standard of the brass industry is the American Society for Testing Materials' Specification B154, which requires immersion for 15 min. in a solution of 100 g. mercurous nitrate acidified with 10 ml. nitric acid (1.42 specific gravity) made up to 1 liter. Various Government specifications also add directions for examining the test specimen after the deposited mercury is volatilized, a procedure necessary to detect very small cracks, otherwise covered up.

Certain manufacturing and testing conditions have a measurable influence on this test, and there has been a great deal of excellent work on the effects of various cleaning methods, time of immersion, temperature and concentration of solution. All this has contributed much to the knowledge of the subject. There is not time nor space for detailed discussion, so reference is made to the suggested reading list on page 886.

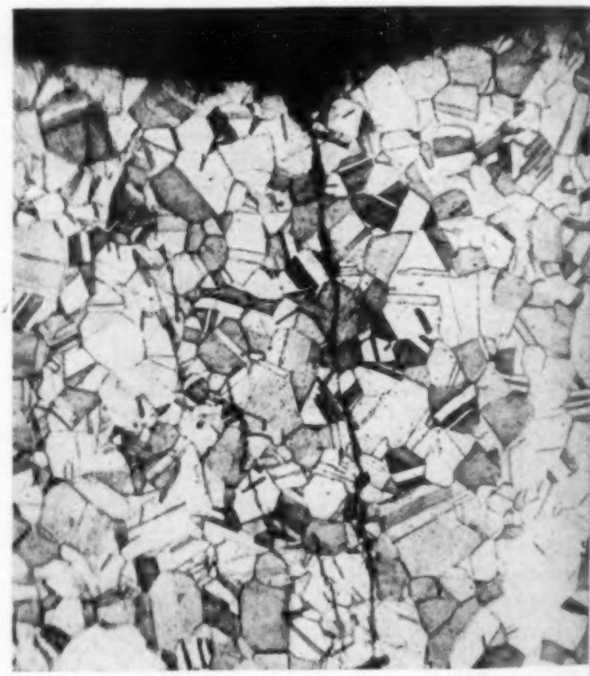

Fig. 23—Fatigue Crack in Fine Grained Brass, Starting at a Corrosion Pit. Note that the course of the fissure is trans-crystalline. Magnified 250 diameters

It is pertinent, however, to discuss the question of interpretation of the test in the light of expected usage and service of the parts being tested. In this connection, there is a sharp line of cleavage between war goods and other manufactured parts. All will agree that war goods, such as cartridge cases, primers, fuse and booster parts, are examples of items wherein it is highly

*Table and figure numbers are consecutive in the entire series of articles.

Fig. 24 — Combination Inter-Crystalline and Trans-Crystalline Crack in Aluminum Brass Condenser Tubing, at 500 Diameters, Caused by Ammonia and External Stress. Courtesy Schenectady Works Laboratory, General Electric

necessary to avoid cracking and, as such, are subject to rigid testing methods and minute inspection. This is not necessarily true of material outside this category.

From this viewpoint the mercurous nitrate test is, then, *a means of indicating susceptibility*, not necessarily an arbitrary test which does or does not produce a crack however minute. As an example: A part which cracks within 5 min. with audible sound when immersed can generally be judged to be in such a condition that stress relief is advisable, even for the general run of commercial articles. However, microscopically fine cracks, appearing only when mercury is removed, are a condition indicating that failure would only occur under severe corroding conditions.

However, there is not sufficient experimental evidence as yet to permit one to predict the expected service life, knowing the length of time before cracking occurs in the test. Under the conditions of exposure in most outdoor atmospheres, experience shows that long service life without failure may be expected in parts which, when tested in mercurous nitrate, emerge with only minute cracks.

If cracking has occurred in service, then the question arises as to the proper means of identification — how can we be sure it is an example of stress corrosion? As previously stated, characteristic "season cracks" occur longitudinally in tubular articles (in cups they start at the rim and peter out part way down). They are usually ragged in appearance. Under the microscope the identification is more positive. Under most conditions the crack will follow the grain boundaries and there will be no evidence of crystal deformation (the latter being more typical of failure due to overstress). By way of further identification, a crack caused by fatigue travels *across* the crystals. In other words, season cracking is inter-crystalline, and fatigue is trans-crystalline (see Fig. 22 and 23).

There can be, however, a condition which cracks both between and across the grains at one and the same time, and thus far this seems to be typical of the action of ammonia on an externally stressed part. Figure 24 shows the result of an experiment at the Schenectady Works Laboratory of the General Electric Co. Note the presence of some trans-granular cracks. However, the presence of numerous inter-crystalline cracks alongside and across the main fissure, especially near the surface, prevents this being mistaken for a fatigue failure. In the G. E. tests specimens were exposed to ammonia vapor while bent into U shape. The alloy is aluminum brass used for condenser tubing (76% Cu, 2% Al, balance zinc, with arsenic added to inhibit dezincification).

In Summary

1. Season cracking can occur when
   (a) Metal composition is inherently susceptible
   (b) Internal or external stress exists, above a certain threshold value
   (c) Corrosion is present, generally due to certain agents.
2. Failures may be avoided by
   (a) Use of non-susceptible alloys
   (b) Thorough cold working
   (c) Stress relief annealing or recrystallization.

3. Method of testing for cracking susceptibility requires immersion in mercurous nitrate solution, and should be used with due regard to use of the parts being tested.

4. Service failures may be identified microscopically by the most typical inter-crystalline cracking, although ammonia may cause a dual inter-crystalline, trans-crystalline fissuring.

Suggested Reading

1 (A). W. Lynes, "Comparative Value of Arsenic, Antimony and Phosphorus in Preventing Dezincification", Proc. Am. Soc. Testing Materials, Vol. 41, 1941.

(B). H. Rosenthal and A. L. Jamieson, "Mercury Cracking Test — Procedure and Control", Proc. Am. Soc. Testing Materials, Vol. 41, 1941.

(C). H. P. Croft, "Influence of External Stresses on Tendency of Brass Wires to Stress-Corrosion Crack, as Indicated by the Mercurous Nitrate Test", Proc. Am. Soc. Testing Materials, Vol. 41, 1941.

2. H. P. Croft and G. Sachs, "Stress Cracking of Brass", Iron Age, March 11 and 18, 1943.

3. D. K. Crampton, "Internal Stress and Season Cracking in Brass Tubes", Am. Inst. Mining Met. Engrs. Tech. Pub. 297, 1930.

4. Alan Morris, "Stress-Corrosion Cracking of Annealed Brasses", Am. Inst. Mining Met. Engrs. Tech. Pub. 263, 1930.

5. H. Rosenthal and A. L. Jamieson, "Stress-Corrosion Cracking of 70-30 Brass by Amines", Am. Inst. Mining Met. Engrs. Tech. Pub. 1660, 1944.

Explosibility of Metal Powders*

By Irving Hartmann, John Nagy and Hylton R. Brown

THE FIRST REQUIREMENT for an explosion of a metal powder is dispersion of the powder as a cloud in air, and the important point is the minimum density (lower limit of explosibility) that such a cloud must have to permit ignition. This density of cloud will vary with particle size, uniformity of dispersion, comtamination of the material by impurities, strength of the source of ignition and time of contact, the reactivity of the particles towards oxygen, and their specific gravity. In the tests to be described the effect of specific gravity is eliminated by comparing the minimum concentration with that required to consume all oxygen from air, and the effect of particle size is reduced by using only fine powders — 90% or more through a 200-mesh sieve.

On this basis the lower limit of explosibility of magnesium samples is 5 to 6% of the quantity required for complete combustion in air; atomized tin, 9 to 11%; aluminum, titanium and iron samples, 11 to 13%; zirconium, 19%; manganese, 22%; antimony, 30%; zinc, 42 to 44%; and silicon, 65%. In general, the less the reactivity of the metal toward oxygen, the higher the percentage concentration necessary to permit reaction. Tin is an exception.

Effect of Particle Size on the lower limit of explosibility is illustrated by comparing a number of the magnesium samples thus:

Through 200 Mesh	Minimum Explosive Concentration	Ignition Temperature
1%	0.125 oz. per cu.ft.	1165° F.
15%	0.060	—
40%	0.040	—
92%	0.025	1060° F.

Ignition Temperature — To ignite a cloud of metal powder there must be a source of ignition having sufficient temperature and heat energy. Minimum ignition temperature for powder of a given metal will vary with size of particles, time

*From R. I. 3722, U. S. Bureau of Mines, "Inflammability and Explosibility of Metal Powders".

of contact with source of ignition, density of the cloud, and presence of impurities.

Many tests were made in equipment long used for studying explosibility of coal dusts; it consists of a heated tube through which are blown measured clouds of dust suspended in known atmospheres. Temperature is increased, test by test, until a flame results. This represents one extreme, with sufficient temperature, but much more heat energy than required (compared with ignition by electric spark, with high temperature and low energy). Results are in the fourth column.

order as ignition temperature, and there is no reason why it should be. Consider any dust having ignition temperature below 1290° F. When a cloud thereof is blown through the furnace the dust ignites and burns. The flammability test determines how much inert dust must be mixed to prevent combustion, and the reactivity of the metal toward oxygen at elevated temperatures will be a factor. For example, the ignition temperature of antimony was 780° F., but at 1290° — the temperature of the test furnace — 65% inert stopped combustion. On the other hand, a magnesium sample had an ignition

Relative Flammability and Explosibility of Metal Powders

Metal Powder	Relative Flammability (% Inert)		Ignition Temperature of Dust Cloud	Maximum Pressure	Maximum Rate of Pressure Rise; Psi. per Sec.
	In Furnace	In Spark Tube			
Zirconium, milled	90+	90+	Room *(a)*	42 psi.	2570
Magnesium, stamped	90+	90+	970° F.	72	4760 *(b)*
Magnesium, milled	90+	90	1005	65	3160
Dowmetal, milled	90	90	805	56	2570
Magnesium-Aluminum, milled	80	78	995	62	3000
Aluminum, stamped	60	80	1195	62	5700 *(b)*
Aluminum, atomized	10	78	1290	58	2250
Titanium, milled	55	78	895	52	1640
Iron, reduced	90+	55	600	36	430
Iron, carbonyl	85	60	610	31	1200
Manganese, milled	40	25	840	31	400
Zinc	35	45	1110	36	1350
Silicon, milled	0	33	1425	62	1180
Tin, atomized	10	30	1165	34	850
Antimony, milled	65	18	780	20	150
Lead, stamped	20	—	1075	—	—
Lead, atomized	0	—	1310	—	—
Cadmium, atomized	18	—	1060	—	—
Copper, reduced	3	—	1290	—	—
Iron, milled	0	—	1435	—	—
Chromium, milled	0	—	1650	—	—
Comparative Figures for Organic Dusts					
Pittsburgh coal	90+	65	1130	46	780
Corn starch	90+	80	715	51	1590

(a) Ignition may have resulted from static electricity in dust cloud.

(b) These extremely high values should be accepted with caution because of possible errors in determining maximum slope of pressure-time curves.

Relative Flammability is determined in a cut-and-try method when holding the above described furnace at 1290° F. As a first step the pure metal dust is tested. If it burns, mixtures containing increased quantities of fuller's earth are tested until there is found the minimum percentage that will prevent ignition of the metal powder in four successive trials. Results are shown in the second column of the table. The next column contains results of similar tests on ignition in a pyrex tube by a high voltage continuous spark using 20 watts of power.

Relative flammability is not in the same temperature of 1165° F., and at 1290° 90% inert could not prevent flame. Flammability shown as 90 + in the table means that a mixture burned even when containing 90% inert.

In most cases the heated wall surface of the furnace is a more potent source of ignition than the sparks of the open-spark tube; compare columns 2 and 3. Exceptions are stamped and of atomized aluminum, titanium, zinc, silicon and tin. All these, except titanium, have relatively high ignition temperatures.

Flammability of organic dusts *(See p. 930)*

Teamwork Over Tunisia

Two Lockheed "Lightning" P-38 Fighters escorting one B-17 bomber, the Lightning proving too versatile to be confined to its original function as a high altitude interceptor

About one-third the weight of a modern fighter's fuselage is steel, and castings comprise a substantial fraction of this. The author outlines their principal requirements and debates the "casting versus forging" problem

Aircraft Requirements of Steel Castings

THE SAUVEUR MEMORIAL LECTURE, which I delivered before the Boston Chapter late in October, 1943, was entitled "The Progress of Metallurgy and Its Problems in Aircraft". One portion of this address has already been published in *Metal Progress,* devoted to aluminum. Another portion discusses the applications of magnesium.* In all this material I attempt to indicate some leading considerations which must be kept in mind when a structural designer in the aircraft industry is considering the adoption of an "improved" variety of a well-known and reliable alloy, or new but relatively untried alloys of attractive properties. These remarks were made and published without the slightest animosity toward any producer or his product; admittedly they were the expressions of a conservative organization, for in aeronautics safety must be achieved up to the very limit of the capacity and endurance of all parts of the craft. Our hesitation in following the stimulating suggestions of metal producers, therefore, is due primarily to uncertainty; some of our doubts can hardly be resolved short of actual experience in fabrication and use — and war-time is not very conducive to this type of experimentation. At any rate, the situation I am endeavoring to describe existed as of mid-1943. Developments are continuing without pause, and no doubt the future will find answers to many of the then unsolved problems.

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In the first article some brief remarks were made, in the above spirit, about the chances that wrought alloy steel might be used to a greater extent in airframes. In the present installment, the subject will be expanded to cover other varieties of steel, principally castings.

It is well known that this country has faced a serious shortage of steel forging facilities, right in the midst of a feverish activity to produce war materiel. This circumstance brought forth the consideration of steel castings as substitutes for forgings. Soon the problem took on much greater significance than mere expediency of substitution, because aircraft engineers would *rather* stay away from castings, and for reasons which are understandable:

First, the overall properties of cast material do not equal those of forgings. (Let's accept that as a general statement, true in spite of exceptions that may exist in extreme cases.) Second, the attempt to produce castings of aircraft quality was undertaken by concerns some of which were definitely lacking in understanding of the reasons for required quality as well as lacking in technical ability.

An arbitrary safety factor of two for *all* castings has been in effect, but has been recently reduced.† The comparison of the properties of the cast versus forged metal would not justify

*Editor's Note: This section is still being considered by the Censor, but we hope it will be cleared for publication in the June issue.

†"Safety factor of two" might be misinterpreted by non-aircraft engineers. It is really an *extra* safety factor, as compared with forgings, for example.

this discrimination; it is obviously intended that this factor should also protect against *uncertainty* of the casting's quality, so it would seem that the very premise of the safety factor is negative and argumentative: *(a)* It admits, by inference, that steel foundries are not capable of producing castings without defects; *(b)* it strengthens the prevalent opinion (justified by past experience) among aircraft engineers that sound castings may not be expected with confidence; *(c)* and finally it penalizes the part on the basis of weight.

Obviously, conclusion *(a)* is incorrect. Much has been accomplished by certain progressive companies in a few past years. Castings free of internal and external defects can be and are produced. However, it should not be assumed that *every* design or *every* part can be successfully made, and I believe that at least part of the difficulties can be traced to this erroneous assumption. I am not prepared to defend the point that foundrymen should be capable of determining which design *is* and which *is not* suitable for a casting. At any rate, 1943 has seen definite progress in the attempts to develop steel castings for aircraft, both by static and centrifugal practice. The importance of the objective — which is to prove or disprove the utility of *controlled quality* castings for use in aircraft structural components — cannot be overemphasized. In my opinion, the cost of forgings (which, in reality, is cost of forging dies) will be unduly burdensome when production gets down to post-war figures.

Even today we should not continue to suffer undue weight penalties. It is understood that if steel castings can be had with physical properties that can take care of stress requirements, the factor of safety would not be necessary except to safeguard against what I have termed the uncertainty of casting quality. In other words, the extra factor of safety for castings could be reduced or perhaps even eliminated if:

1. Certain required physical properties are developed by the selection of proper analysis and heat treatment.
2. Castings free of defects can be made.
3. Assurance can be had that the quality as conditioned by (1) and (2) will be maintained.

As of mid-1943 and depending on the application, castings were used by Lockheed Aircraft Corp. in two classes:

Class	Tensile Strength	Yield Strength	Elongation in 2 In.
(a)	100 to 125,000	80% of T.S.	25 to 30%
(b)	150 to 170,000	80% of T.S.	10% min.

No difficulty has been experienced in meeting the above requirements, except in elongations for high tensile strength castings, class *(b)*. Usual values for a number of steels which have been heat treated in the conventional manner of quench and draw reach only 7 or 8%. By "double heat treatment" — that is, homogenizing at 1850° F., followed by proper quenching and tempering — the prescribed properties can be attained. The impact values by notched bar in Charpy test are between 12 and 20 ft-lb., indicating fair toughness.

With the cooperation of several progressive companies the development work on sample castings proved that they either had no defects revealable by X-ray methods of very careful technique, or that whatever imperfections were detected by radiography were of such nature as to reject none of the castings. In itself this achievement is of little significance until it can be demonstrated that careful control during the development stage can be carried over into production. It is in this circumstance that the difficulties may be expected, since it is a matter of technical ability, the accumulation of service records, *and* economics.

Those of us who became interested in the technical aspects of this problem soon realized that the experiences of other industries would not be convincing to aircraft men. While comparisons are often illustrative they are not necessarily conclusive; the fact that castings have been adopted by certain industries, like railroads, and rendered satisfactory service, is no proof — only a favorable sign that they might be equally successful in airframes.

Forging of Casting "Blanks"

Attention is also being given to the advisability of using "semi-forgings" or "semi-castings". The idea — quite old, I hasten to add — is to forge oversize castings to finish dimensions. It appeals to some of us for the technical reason that whereas the *static* properties of castings can be made sufficient and, theoretically, forgings should therefore hold no advantage, yet the impact, fatigue and toughness of forgings *are* superior. The latter properties are also most affected by surface conditions (such as notches) and peculiarities of design. It is to be anticipated that properly heat treated cast material will be able to withstand the required service conditions in the interior of the part. The problem, therefore, is to provide a given part with forged outside, thus securing the advantages of forged material at the surface, leaving the inner portion much as it was, or of steel which has been worked to a considerably less extent.

Strictly preliminary data — experimental

work does not have priority these days — indicate encouraging results. Obviously, a peace-time development of this kind is to stand or fall on an economic basis, assuming that parts so produced will be as acceptable as forgings to the stress engineer. Production schedules of war-time, shortages of production materials (principally dies) and facilities, introduce abnormal yet vital factors which determine the merit of the undertaking more than the unit cost of the product. The various phases of work in the field of castings undertaken because of its temporary importance will have, I am certain, permanent value. We are working toward the development of precision steel castings, borrowing this term from a well-established industry casting certain highly alloyed ferrous and non-ferrous metals in permanent molds.

Through development work, stage by stage, the aircraft industry hopes to achieve superiority of product, consider its suitability to our problems, and if found satisfactory, emphasize and inaugurate control in production, accumulate service records, decipher "quality standards" — a program of large magnitude!

Centrifugal Castings

The contingencies of war gave impetus, in my judgment, to the intensive studies of centrifugal castings. In some instances this has been with notable success. Facts learned through the experience of others fully justified experimentation with those aircraft parts which, by virtue of their design and dimensions, were particularly suitable for the process. I know of several successful accomplishments and the number of attempts is expanding. In particular, much interest is displayed in centrifugally cast landing gear parts, the outer cylinder of the oleo tube, the lower portion of the knuckle, the axle and the brake flange — the latter three cast as one part. This program has been of intense interest and immediately brought forth the comparison between static and centrifugal castings.

Miscellaneous Problems

This report on various metallurgical subjects will be incomplete if a few other important topics are not mentioned — even if only briefly.

The great need to preserve strategic alloying elements in the first two years of war resulted in the strictest economy in the use of some such materials as stainless steels. Even fire walls, together with many parts in the immediate vicinity of the power plant, were converted from stainless to aluminized low carbon steel. Although strictly a measure of war-time economy, we have received so far no adverse service reports. If these satisfactory findings persist, the necessity for stainless in the above mentioned parts will have to be studied. War-time is not conducive to thorough evaluation of emergency measures and substitutes and, consequently, peace-time requirements for huge passenger and cargo planes will have to be most carefully studied before the war-time substitution can be adopted.

There is no question, as far as I can ascertain, that stainless chromium-nickel steel and inconel are the only alloys which can now be used for exhaust manifolds and like parts. Even with these superior materials, the service records of manifolds on modern, high powered engines show occasional difficulties. This is not surprising in view of the much more severe conditions imposed by required service. Undoubtedly the safe disposal of hot exhausts from high octane gasolines is becoming a more and more serious problem. The proposed use of enameled steel does not seem likely to be the answer.

I must also mention "pressure welding", a relatively new method in airframe work, but quite old in fundamental principle. It is a butt welding process in which the heat is supplied externally and the parts to be welded are pressed together. The main advantage of this process is that it apparently permits the welding of such large areas that could not be handled on flash welding machines. Considerable success has been reported in the application of this process to the welding of landing gear parts, and welding of tubing to castings.

The reader may wonder, by this time, if it is not a hopeless task to face all these problems. It is no more so than in countless other endeavors to win the war and then permanent peace. Individual endeavors are merging into united efforts. Through the formation of the Aircraft War Production Council and its Engineering Committee, various problems, common at present to all of us, are evaluated, appraised and assigned for quick solution. The findings and the experience of any one aircraft organization fighting on the home front are the property of all. All of them are contributing their share. This share is the result of the knowledge, experience and hard work of many individuals. In accepting your invitation to join you in honoring the memory of Dr. Sauveur I made it clear to my superior officers and my associates that I shall merely be a spokesman for the women and men who designed, nursed, built and are building in ever increasing numbers the fighting P-38.

Down-Grading of Aluminum Casting Alloys

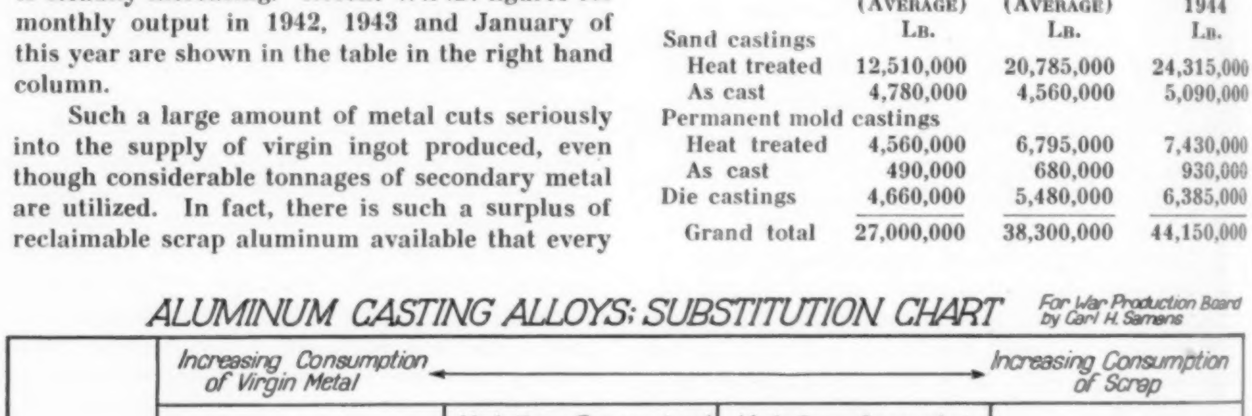
MANUFACTURE of aluminum castings was at an unprecedented level in 1943, but is steadily increasing. Recent W.P.B. figures for monthly output in 1942, 1943 and January of this year are shown in the table in the right hand column.

Such a large amount of metal cuts seriously into the supply of virgin ingot produced, even though considerable tonnages of secondary metal are utilized. In fact, there is such a surplus of reclaimable scrap aluminum available that every effort should be made to consume it. This would

	1942 (Average) Lb.	1943 (Average) Lb.	January 1944 Lb.
Sand castings			
Heat treated	12,510,000	20,785,000	24,315,000
As cast	4,780,000	4,560,000	5,090,000
Permanent mold castings			
Heat treated	4,560,000	6,795,000	7,430,000
As cast	490,000	680,000	930,000
Die castings	4,660,000	5,480,000	6,385,000
Grand total	27,000,000	38,300,000	44,150,000

ALUMINUM CASTING ALLOYS: SUBSTITUTION CHART

For War Production Board by Carl H. Samens



Note: Alloys enclosed within heavy lines are susceptible to heat treatment; those within a light line are not.

be true conservation, even though there were no war-time shortage of labor, raw materials and new metal and alloying constituents. It is always good economy to use the lowest grade of material that will do the job.

The chart on opposite page and the table suggest possible substitutions in aluminum casting alloys. Suitable ingots for alloys placed toward the right side of the chart contain less and less virgin metal. If the high mechanical properties, specific physical characteristics, maximum resistance to corrosion, or castability inherent in an alloy placed toward the left of the chart are not essential, it is a contribution to the war effort and the national economy to use an alloy nearer the right.

Approximate Equivalent Specifications for Aluminum Casting Alloys

(Not in all cases interchangeable for procurement and inspection)

Aluminum Sand Castings

Commercial Alloy	Type Composition	Federal QQ-A-601 & E-QQ-A-601; Class	Army Ordnance AXS 784; Class	Navy 46-A-1 (INT) (5/1/42); Class	Aeronautical	S.A.E. Specification Number	A.M.S. *(a)*	A.S.T.M. B26-43T Alloy
220	Mg 10	—	—	—	AN-QQ-A-392-2	324	4240-A	—
356	Si 7; Mg 0.3	3	—	3	AN-QQ-A-394-2	323	4217	SG1
214	Mg 3.8	5	—	5	AN-QQ-A-402-2	320	—	G1
142 *(b)*	Cu 4; Mg 1.5; Ni 2	6	—	—	AN-QQ-A-379-2	39	4220-A *(c)*	CN21
355	Cu 1.3; Si 5; Mg 0.5	10	—	—	AN-QQ-A-376-2	322	4210-B *(d)*	SC21
195	Cu 4.5	4	—	4	AN-QQ-A-390-3	38	—	C1
43	Si 5	2	—	2	AN-QQ-A-405-3	35	—	S2
40E	Mg 0.5; Zn 5.3; Cr 0.5	—	—	1	—	—	—	ZG41
Sec. 355 and Modifications	Cu 1.5; Si 6.5; Mg 0.5	—	—	—	—	—	—	—
Sec. 195	Cu 4.5	13	13	4a	AN-A-5	E-325	—	C2
X113-A334 and Modifications	Cu 3; Si 4	14	14	—	AN-A-4	E-326	—	—
108	Cu 4; Si 3	8	—	—	—	—	4234	—
212	Cu 8; Fe 1; Si 1.2	9	—	—	AN-QQ-A-399-2	36	—	CS21
112	Cu 7; Fe 1.2; Zn 1.7	—	15	—	—	33	—	—
12	Cu 7.5; Fe 1.4; Si 1.5; Zn 2	—	15	—	—	33	—	CS22

Permanent Mold Castings

Commercial Alloy	Type Composition	Federal QQ-A-596; Class	Army Ordnance	Navy 46-A-15 (INT) (2/1/42); Class	Aeronautical	S.A.E. Specification Number	A.M.S. *(a)*	A.S.T.M. B108-43T Alloy
356	Si 7; Mg 0.5	8	—	8	—	323	4284	SG1
A214	Zn 1.8; Mg 3.8	—	—	—	—	—	—	—
142 *(b)*	Cu 4; Mg 1.5; Ni 2	3	—	3	AN-QQ-A-379-2	39	—	CN21
A132	Cu 0.8; Fe 0.8; Si 12; Mg 1; Ni 2.5	9	—	9	AN-QQ-A-386-2	321	—	SN41
355	Cu 1.3; Si 5;Mg 0.5	6	—	—	AN-QQ-A-376-2	322	4280-A	—
B195	Cu 4.5; Si 2.5	4	—	—	AN-QQ-A-383-2	380	4282-A	CS4
43	Si 5	7	—	7	—	35	—	S2
C132	Cu 4; Si 12	—	—	—	—	—	—	—
122	Cu 10; Fe 1.2; Mg 0.2	2	—	2	—	34	—	CG1
Sec. 355 and Modifications	Cu 1.5; Si 6.5; Mg 0.5	—	—	6	—	—	—	—
Sec. B195	Cu 4.5; Si 2.5	—	—	4	—	—	—	—
A108	Cu 4.5; Si 5.5	5	—	5	—	—	—	SC1
C113	Cu 7; Fe 1.2; Si 3.5; Zn 2	1	—	1	—	33	—	C3

Aluminum Die Castings

Commercial Alloy	Type Composition	Federal QQ-A-591; Class	Army Ordnance	Navy 46-A-14 (INT) (2/1/42); Class	Aeronautical AN-QQ-A-366-4; Class	S.A.E. Specification Number	A.M.S. *(a)*	A.S.T.M. B85-42 & EA-B85 Alloy
13X	Si 12	2	—	2	Al-13X	—	4290-A	—
218	Mg 8	7	—	7	Al-218	—	—	—
13	Si 12	1	—	1	Al-13	305	—	V
43	Si 5	3	—	3	—	304	—	IV
A379	Cu 4; Si 7	10	AXS 679 (Rev. 3)	—	Al-85X	E-306 E-308	4291 —	LXXIX-B LXXIX-A
85	Cu 4; Si 5	5	—	5	Al-85	307	—	VII-A
81	Cu 7; Si 3	4	—	4	—	312	—	XII

NOTES: *(a)* A.M.S. means aeronautical material specification, issued by Society of Automotive Engineers.

(b) Alloy 142 is solely for applications at elevated temperature — as for cylinder heads; no substitution is possible.

(c) 4220-A applies to the castings with solution treatment; 4220 to solution and stabilizing treatments.

(d) 4210-B applies to the aged sand casting; 4212-B to solution and precipitation treatment; 4214-A to solution treatment and over-aged.

A round table discussion on "Special Finishes and Metallic Protection" was held at the Chicago ⊕ Convention, last October. Some of the speakers cannot be reported except in summary; however the complete group on chemical coatings is presented below

Protective Chemical Coatings on Metals

Cleaning Prior to Finishing

By James Rowan Ewing
Assistant to President
Solventol Chemical Products, Inc.

FOR YEARS the metal industries have made great efforts to provide the best possible metals and combinations thereof for their finished products. Also, the machine tool industry constantly devises more efficient tools for working and finishing those metals. However, unless they are properly cleaned in the course of their fabrication and finishing, much of these values can be lost, not only through spoilage of surface, but through loss of efficiency in the ultimate function. Consequently, the problem of metal cleaning and the conditioning of metallic surfaces during and after manufacture demands the best engineering, research and cooperation by the metal industries and the sources of cleaning agents, equipment and processes.

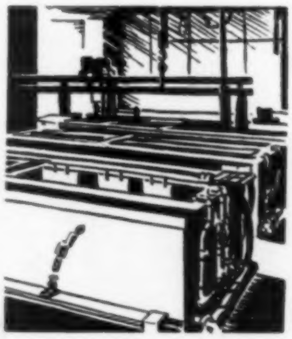
The subject is so broad that a brief discussion must be limited to one method. Consequently these remarks will be confined to the fundamentally new principle available today which is the result of the introduction of synthetic organic chemicals, which are combined with distillates and solvents and applied in a water medium, to the end that *one* operation in a spray wash completely cleans and conditions the surface. By complete cleaning and conditioning is meant removing and rinsing off of all soils, including greases, oils, inerts, compounds, or any foreign matter, plus the passivation of the cleaned metal surface against atmospheric rust or corrosion during and between processing operations, and up to final finish, coating or assembly. For years past any result equivalent to this has been achieved only by a chain of separate operations and handlings.

For a specific example consider cleaning of automotive ring and pinion gears. As late as 1941 the mass production sequence included a dip in hot seal oil or kerosene, two stages of alkali wash, and a final water rinse, the rinse including a mixture of soluble oils. The requirement was a gear surface free of emery particles prior to the sound room test. In contrast, this new principle was applied to this same problem as early as 1940 by one major automobile manufacturer. A simple two-stage washing machine was used in the revised operation, and completely removed red leads and provided a dry, bright finish, and furnished a metal passivated against atmospheric attack.

A second important contribution to the entire scope of metal cleaning is the possibility of its use in proper modifications for cleaning and conditioning any metal or alloy, including brass, bronze, copper, magnesium and aluminum. To demonstrate this, I cite an operation as early as 1939, dealing with the difficult problem of removing stubborn, caked buffing compound from polished zinc die cast automotive hardware parts

prior to bright nickel and chromium plating. It was not only a stubborn cleaning problem, but the cleaning agent must not react on the delicate polished zinc surface. This operation, replacing multiple operations formerly used, eliminated re-racking and tack wiping, and completely removed imbedded buffing compound, and produced clean parts, free from water break and ready for immediate plating. When necessary, the parts could be held for as long as 8 hr. before plating without any harmful atmospheric attack.

These early applications, prior to 1941, in the mass production industry, provided a necessary background to solve many problems connected with the high finish necessary on gas engine parts, sub-assemblies, ammunition, and the multiple items involved in the war program. The old methods were not only expensive in equipment and labor, but sometimes involved the danger of toxic working conditions, rancid solutions, and distressing dermatitis. It is even more true of war munitions than peacetime equipment that the product must go through numerous inspections (including magnetic and X-ray), multiple machining, grinding and polishing operations, storage (long or short) and final preparation of the metal for its ultimate permanent coating, whether it be oxide, paint, electroplate, or any one of the wide range of permanent or semi-permanent coatings.



There is no time to cite more than one of the problems met by the Ordnance Department: In important parts it is necessary for the final conditioning of the metal surfaces to insure against finger marking or rust prior to the application of semi-permanent rust preventive oils and greases in preparation for export. An operation, utilizing the principle under discussion, automatically eliminates the necessity for any additional operation to meet this requirement.

Developments of this nature and their multiple applications need continued joint research of foremen, process engineers, metallurgists and suppliers, with mutual recognition of the problems which must be solved. The high standard of metallic surface requirements in the war program has best demonstrated the results which can be obtained with this continued cooperation, and we believe that such cooperation will continue in the future with reduced costs, better products, and better functioning.

Chemical Coatings on Steel

By V. M. Darsey
Technical Director
Parker Rust-Proof Co.

CHEMICAL COATINGS on iron and steel result from an actual chemical reaction with the metal to form therewith a non-metallic coating. Thus they are contrasted to metallic plates and paint coatings which generally do not require *chemical* combination with the base metal. In many instances chemical coatings have proved a satisfactory alternate finish on steel articles which formerly required such vital metals as copper, nickel, chromium, tin, cadmium and zinc for their protection. In general, the equipment and chemical reagents needed for the production of such coatings are simple, readily available and for this reason have expedited the finishing of many articles. The value of certain chemical coatings has been established by past use and performance; others will require additional use for proper evaluation. Many of their new or recent uses will be continued after the war; the extent of such use will depend upon economic factors as well as performance records.

Phosphate and Oxide Coatings — There are many types of true chemical coatings available for metal surfaces. A book could be written about them — in fact, books *have* been written. I must confine my remarks to only two of them, namely, phosphate and oxide coatings.

Phosphate coatings result from the treatment of properly cleaned iron and steel articles in a balanced phosphate rust-proofing solution, whereby the metal surface is converted to a non-metallic phosphate coating.

Oxide coatings generally result from the treatment of iron and steel articles in a concentrated solution of caustic soda containing an appropriate oxidizing agent, at temperatures around 250 to 300° F. for a sufficient length of time to convert their surfaces to a black oxide coating.

Phosphate Coating for Corrosion Protection — Since discontinuing the manufacture of many civilian articles such as automobiles and refrigerators, the use of phosphating for protecting

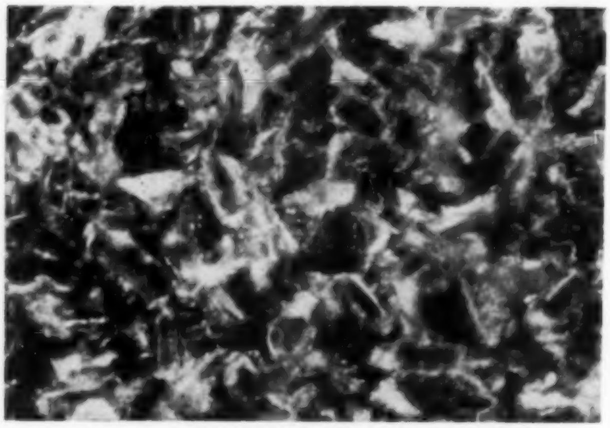


Fig. 1 — Phosphate (Parkerized) Coating Magnified 400 Diameters on Sheet Steel

war articles against corrosion has far exceeded its use as a base for paint. Many ordnance items require a finish that is not only protective but must reflect very little light and not interfere with normal operating efficiency. Paint is a less satisfactory finish for functional components than oil on phosphated surfaces. On such articles as machine guns, rifles, ammunition links and clips, phosphating has proved an excellent finish and has resulted in the conservation of much zinc previously used for their protection. In Fig. 1 is shown a typical coating, promoted by us under the name "Parkerized" coating, representative of this type of corrosion resistant finish.

Phosphating as a Base for Paint — The combination of phosphating and painting is serving as a finish on many war articles which formerly consumed critical metals for their protection. Years of experience has proved the value of this treatment to promote the durability of paint and enamel applied to steel surfaces.

Phosphate Coating for Wear Resistance — The use of phosphating for reducing wear on machine parts has increased rapidly in the past few years. A treatment marketed as "Parco Lubrizing" is used for forming a wear resisting coating on bearing surfaces consisting chiefly of an admixture of iron and manganese phosphates. The uniformity and penetration of the metal by the phosphate coating, and its affinity for oil, are believed the chief reason for reducing wear on friction surfaces. Many guns and breech parts as well as other articles for the armed services are phosphated to reduce wear and corrosion as well as to promote better functional operation. In Fig. 2 is shown a polished piston surface before and after treatment.

Phosphate Coated Steel for Can Manufacture — The phosphating of steel strip or sheets is accomplished by feeding the properly cleaned stock through a series of rollers within a closed machine and spraying the phosphating solution on the steel. The coating resulting from this method of application is unusually fine grained in structure, and will withstand drawing, bending, and rolling operations encountered in the manufacture of caps, crowns and can bodies. This application of phosphating is conserving a large percentage of the tin ordinarily used for such containers. Phosphating, with or without lacquering, has proved to resist satisfactorily the action of many foods and substances formerly packed in tinned steel containers. In Fig. 3 is shown ordinary black plate steel before and after "Bonderizing" by this method of application.

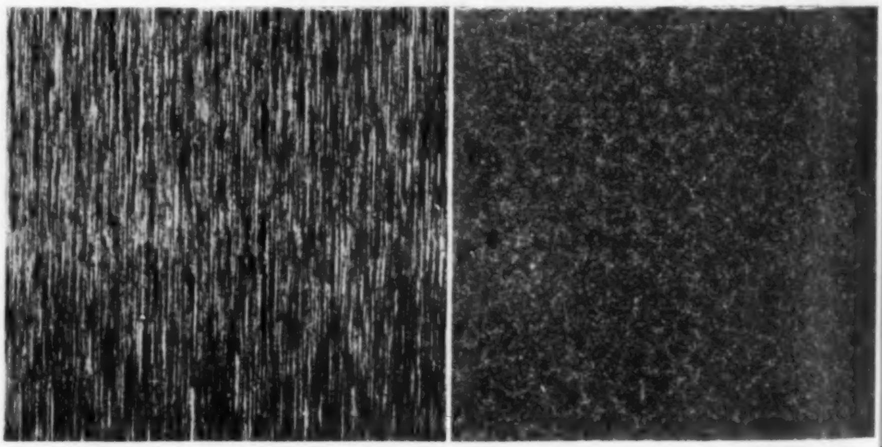


Fig. 2 — (Left) Is the Surface of a Honed Cast Iron Piston, Degreased and Dry Rag Wiped, Magnified 10 Diameters, Photographed With Oblique Light. Right is same after treatment in Parco Lubrizing solution, producing a coating with high affinity for oil

Phosphate Coating an Aid in Drawing Steel — The shortage of copper and brass has made it necessary to manufacture many articles formerly made of these materials from steel. For cold drawing of steel, the combination of a phosphate coating and a lubricant has proved a valuable aid and extended the life of the dies.

The lubricant is adsorbed by the coating, thus providing a film of lubricant between the die and the steel being drawn. Approximately

one-half the phosphate is removed in each drawing operation and the number of draws which can be made successfully without retreatment depends upon the amount of reduction necessary to make the steel part. In general, two or three draws can be made from each application of phosphating. In some instances this process has replaced the use of strategic copper as an aid in deep drawing.

Phosphate Coating Repels Molten Lead — Experience has shown that lead does not stick to the surface of phosphated steel when such articles are drawn in a lead pot. Advantage is taken of this fact in the treatment of certain gun parts which require a uniform appearance and a surface free of lead particles. Phosphating has therefore expedited the production of such articles, as well as reduced their cost.

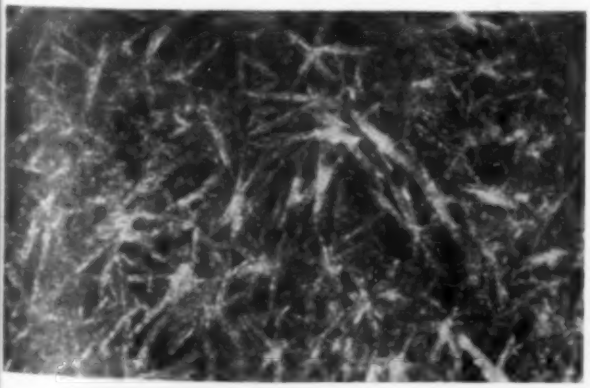
Zinc Coated and Phosphated Steel — If a thin coating of zinc, 0.00005 to 0.00010 in. thick, is electrodeposited on steel followed by phosphating, the sheets are better able to resist corrosion and hold paint. This is accomplished by passing the properly cleaned strip steel or sheets continuously through a suitable zinc plating bath and phosphating equipment. The availability of such processed sheets should increase as more equipment and steel are made available for civilian use. Steel processed in this way, it is believed, will find wide use after the war. In Fig. 4 is shown a representative zinc coated surface and the same surface after "Bonderizing".

Oxide Coating on Steel — Extensive use is being made of black oxide coatings on steel, both for appearance and corrosion protection. This attractive color, plus some rubbing finish such as oil or wax, is serving on many war articles. It is claimed that there are no dimensional changes in such articles, and for this reason parts requiring very close tolerances can have an oxide coating. It is claimed that no chance hydrogen embrittlement results from the oxide coating, and the treatment is suitable for blackening springs and similar hard steel parts.

The requirement in U. S. Army Specification 57-O-2C calls for unoiled black oxide coatings to withstand 30 min. salt spray test without rust, and 2 hr. for the oiled coating.

Time does not permit further discussion of this subject. Some uses of phosphate and oxide coatings have been given, hoping that the information will be new to some who have a problem to solve wherein such coatings can be used.

Fig. 3 — (Above) Is the Surface of Black Plate, Full (Shiny) Finish. This is regular tin can stock at 400 diameters. Below is same material after "Bonderizing" for 10 sec.; coating weight is 82 mg. per sq.ft. Both surfaces magnified 400 diameters



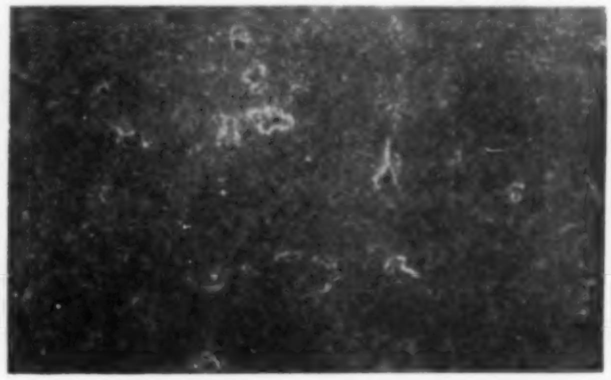
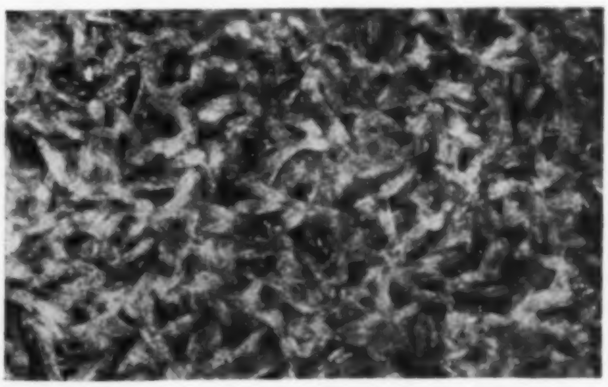


Fig. 4 — (Above) Is the Surface at 400 Diameters of Auto Body Stock Electroplated With 0.00005 In. of Zinc at 25 Amperes per Sq.Ft. Below is the same after 20 sec. in Bonderizing solution



Coatings on Aluminum by Chemical Treatment

By Ralph E. Pettit
Aluminum Co. of America

COATINGS applied to aluminum and aluminum alloy surfaces by chemical treatment usually serve as a base for paint, but in some cases, the coatings are used alone for protection against corrosion. The national war effort has demanded the utilization of every means for maintaining the enormous production schedule, and industry has therefore made increased use of chemical coating processes for aluminum alloys. There are a number of reasons for this trend:

1. The lower cost of chemical treatments, as contrasted with anodic oxidation processes.
2. The difficulty of quickly obtaining equipment for anodic treatment plants.
3. Possible difficulties in obtaining certain materials for the anodic process.
4. Protective coatings can be produced by chemical treatment on pieces which cannot, by reason of their shape and construction, be given an anodic coating.

The Aluminum Co. of America had anticipated these heavy demands, and developed and placed at the disposal of American manufacturers a simple but effective method of oxide coating known as the "Alrok" process. It involves the use of an alkaline coating solution, and then seals the coating with a corrosion inhibiting agent. Such coatings have found important fields of usefulness in the war effort. While they are not the equal of some of the "Alumilite" coatings produced by electrolytic oxidation, nevertheless they are satisfactory for many applications. Practical experience in service has shown that they are adequate as a treatment prior to painting on certain types of wrought or cast alloy structures. U. S. Army Specification 98-20007, Amendment No. 3, approves the treatment for this purpose on alloys for which the anodic coating is not required by the procuring agency.

(For structures subject to severe service conditions, such as pontoons, bottoms of flying boats, and similar applications, the use of coatings produced by anodic oxidation is recommended.)

For gasoline tanks which must be coated on the inside, or lengths of tubing and intricate assemblies which require protection on all surfaces and which would be difficult to finish effectively by the anodic process, Alrok coatings without subsequent painting have been found to provide substantial protection. Likewise on parts with small internal passages, such as liquid-cooled cylinder heads, exhaust manifolds, oil coolers and other parts which are difficult or impractical to treat anodically, chemical coating will provide increased resistance to corrosion. Subsequent painting will further increase the protection.

While the Alrok coating is somewhat less protective than the Alumilite coating, unpainted A17S-T rivets properly finished with the chemical process will pass the joint Army-Navy Specification for anodic coatings, AN-QQ-A-696a, which requires a salt spray test of 250 hr. 17S-T or 24S-T rivets, properly treated by the Alrok process, will pass these salt spray tests provided they are not given more than one heat treatment after coating. When additional heat treatments are required, the coating should be removed and re-applied. When rivets are to be painted, Alrok coatings are substantially as effective as anodic coatings as a base for paint.

Since the chemical process does not require any electric current, it is readily adapted to the bulk or tumbling barrel method for the treatment of small parts. The racking of the larger parts is simple; in many instances large parts are placed upon wood or iron frames or hung from appropriate hooks.

It should be remembered that, while the finish is generally adherent and protective, it is not as thick nor as resistant to abrasion, nor does it give the protection that can be expected of some of the anodic coatings, especially the Alumilite coating. Where previous and accepted practice has been to use bare unpainted metal, the Alrok coating will of course give added insurance against corrosion.

Another process, which comprises immersion in a warm solution of chromic acid, is also used by some manufacturers for surface treatment of aluminum prior to painting and is said to give good results.

Another chemical surface treatment of aluminum as a preparation for painting uses solutions of phosphoric acid with a grease solvent such as an alcohol. These solutions are applied by dipping or swabbing and produce, in all probability, a very thin film of aluminum phosphate. Alone, this film has little protective value, but it does afford a good base for paint.

Surface Treatment of Magnesium Alloys

By W. S. Loose and H. K. DeLong
Metallurgical Dept.
Dow Chemical Co.

IN THE PAST, magnesium alloys acquired a reputation for poor corrosion resistance due to severe salt water tests on materials contaminated with iron and other impurities. This reputation is being lived down by the good service performance these alloys have given, not only in inland atmospheres, but on carrier-based aircraft, on sea planes, and under other corrosive conditions. Normal atmospheric exposure has little effect other than to form a gray discoloration; there is also a slight loss in strength after several years' exposure. (Under the same conditions, bare steel would lose at least as great a percentage of its strength.)

Poor results in early corrosion tests were due to the electrolytic couples set up by metallic impurities, and also to the fact that many castings contained fluxes which, being hygroscopic, attracted moisture and set up electrolytic cells, regardless of the metallic impurity content.

The present increased confidence in these alloys can largely be traced to the development of alloys more resistant to salt water, to improved foundry techniques eliminating flux inclusions, to the improved chemical treatments that have been developed, and to the increased knowledge of variables that affect the protective value of these chemical films. Much of the protection afforded by these treatments lies in their ability to remove impurities from the metal's surface.

The scope of this discussion is narrowed to cover only those chemical treatments which are currently used on Army and Navy contracts and will be directed mainly to pointing out common difficulties experienced in their application, together with suggestions for the elimination of these difficulties.

Chrome-Pickle Treatment

(Dow No. 1; Specification AN-M-12, Type I)

This is primarily a producers' treatment which protects parts during storage and shipment. It consists of immersing the part (or applying the solution locally) for 1 min. at room temperature in a bath of composition:

Sodium dichromate ($Na_2Cr_2O_7 \cdot 2H_2O$)	1.5 lb.
Concentrated nitric acid (sp.gr. 1.42)	1.5 pints
Water	to make 1.0 gal.

After immersion the part is rinsed in cold water, then a hot water dip, and allowed to dry. The resultant coating on clean surfaces is of matte to brassy, iridescent color.

It may also be applied as a spray on parts and assemblies which are too large to put into available tanks. On large parts, the coating may also be applied by brushing on a generous amount of solution for the recommended time.

The operational difficulties and reasons therefor are as follows:

1. **Brown, Non-Adherent, Powdery Coating** — Under proper operating conditions, the oxide compound formed on the magnesium alloy is a thin, adherent film composed of chromium oxide and magnesium oxide. When treating conditions, such as solution concentration or time in the air, are not correctly controlled, a brown, non-adherent, powdery coating may result.

(a) The part may have been in the air too long after applying solution and before rinsing. The air interval should be approximately 5 sec.

(b) The acid concentration may be too high in ratio to the sodium dichromate content.

(c) The solution may have become too hot because of being too small in quantity or because of too many parts going through the bath.

(d) The metal may not have been properly degreased. The brown powder will occur at spots where oil existed.

(e) The solution may have been revivified too many times. The nitrate build-up will cause powdery coatings, particularly on Dowmetal "M" alloy (1.5% Mn), after continued use and revivification of the bath. The bath should be discarded after four revivifications when treating this alloy. Other alloys may be treated in a bath after as many as 11 to 12 revivifications. If parts are being chrome-pickled only for protection during shipment and storage, and will be retreated before painting, the bath may be revivified 30 to 40 times. The necessity for finally discarding this bath will be indicated by excessive sludge in the tank and powdery surfaces on treated articles.

2. **Gray, Non-Adherent, Powdery Coating** occurs on magnesium alloys containing high aluminum (6 to 10%), particularly after precipitation heat treatment. It may occur on as-cast metal but not on solution heat treated metal. The gray powder is $Mg_{17}Al_{12}$, the magnesium-aluminum compound which is not dissolved as readily

as the other alloy constituents; it is therefore laid bare as a finely-divided, adhering powder. The powder is not only a potential fire hazard in grinding but may result in a powdery appearance on the coatings applied later. The last mentioned condition is especially prevalent on Dowmetal "C" alloy (9% Al, 2% Zn, 0.1% Mn). It may be eliminated by:

(a) Using the bath at 120° F. and shortening the treatment time to 10 or 15 sec.

(b) Adding 2 oz. per gal of sodium, potassium, or ammonium acid fluoride to the bath. (A synthetic rubber-lined tank must be used for this solution.) The presence of fluoride limits this treatment to sand, permanent mold or die castings and aged wrought products. On solution heat treated wrought products, the fluoride addition results in inferior paint adhesion.

(c) Solution heat treating the parts before applying the chrome-pickle.

Dichromate Treatment

(Dow No. 7; Specification AN-M-12, Type III)

This treatment provides maximum salt water and marine atmospheric protection. When combined with paint coatings, it offers the simplest and best treatment for maximum protection with negligible dimensional change. It consists essentially of two steps applied as follows, after proper degreasing:

Step 1. Immerse the parts for 5 min. in an aqueous solution containing 15 to 20% by weight of hydrofluoric acid (HF) at room temperature. Rinse in cold running water.

An alternative step, for use on wrought products only, is to immerse the parts for 15 min. in an aqueous solution containing sodium, potassium, or ammonium acid fluoride at room temperature; then rinse in cold running water. This is advantageous because aluminum inserts, rivets, and such like, are not materially attacked; it is also more economical. It should not be used on castings of any type, as inferior protection will result.

Step 2. Boil parts for 45 min. in an aqueous solution containing 10 to 15% sodium dichromate. After boiling, the parts are rinsed in cold running water, followed by a dip in hot water to facilitate drying.

The addition of calcium fluoride or magnesium fluoride to the dichromate bath will improve corrosion resistance, promote film formation, and insure more uniform coating. These fluorides are only very slightly soluble and may be added conveniently by suspending the salt in the bath in canvas bags. Either of these salts will provide the correct amount for proper film formation. When fluoride is added to the chromate bath, the treatment time can be reduced to 30 min. If it is not convenient to suspend a bag of calcium fluoride or magnesium fluoride in the solution, 0.5% by weight of the fluoride may be added initially to the bath; additional amounts can be added from time to time as required, although this is seldom necessary in actual operation.

The operational difficulties usually experienced in processing magnesium alloys with the dichromate treatment and the reasons therefor are as follows:

1. **Loose Powder Coating.**

(a) The hydrofluoric acid bath or the acid fluoride bath may be too dilute. Concentration of free HF should be controlled according to specification. The hydrofluoric acid may also contain appreciable quantities of other acids as impurities, causing the bath to react vigorously and continuously on magnesium.

(b) The pH of the dichromate bath may be too low. It should not fall below 3.8 and preferably not below 4.

(c) Parts may be corroded or oxidized or have flux contaminations. This will result in gray to yellow coatings of a loose nature. Corrosion and oxidation products are not removed by the dichromate process — in fact, they are usually made more readily noticeable, due to the dark color of the coating and the light color of the corrosion product. Corroded, oxidized or badly fluxed parts should therefore be cleaned in 15 to 20% chromic acid prior to the dichromate treatment to remove corrosion or oxidation products or flux contaminations. Such a chromic acid bath is preferably used hot and the treatment time is 2 to 15 min.

(d) Magnesium alloys of high aluminum content may sometimes be covered by a loose gray layer of $Mg_{17}Al_{12}$ compound formed during the initial chrome-pickle. This will also result in loose gray or yellow powdery dichromate coatings, because the hydrofluoric acid and the acid fluoride baths react with the powder to form thick MgF_2 coatings. The MgF_2 may not be completely reacted upon to form the chromate coating during normal immersion in the chromate bath. The gray powder should be eliminated by the producer by proper chrome-pickling as previously described.

(e) Powdery coatings are also formed in some cases when the work is electrically connected to the steel tank holding the dichromate bath. This is due to a galvanic anodizing effect, and parts should therefore be insulated from the container.

(Continued on page 924)

This department, "Bits and Pieces", welcomes notes concerning new ways of doing things to metals, either in shop or laboratory. An ⊕ book of your choosing (other than the Metals Handbook) is the reward for a publishable item

Bits and Pieces

Metallurgicus's Own Pages

At Last—*One* Alloy Steel

I FEEL FORTUNATE in numbering among my friends that almost mythical scientist, engineer and promoter, Martin Seyt, of the Plumbine Smelting Co. Seyt has shown me (pardon the pun!) an interesting article under title of "Making Steel Specifications" in the Feb. 18, 1944 issue of *The Engineer*, by Harry Brearley, honored British metallurgist.

Its principal theme is the prevalence of unwarranted restrictions in British specifications. Fortunately, of course, American specifications are free from such silliness as Brearley cites. Who ever heard any criticism of AN or WD or the other specifications now being used? Be that as it may, one can only say "Amen" to such remarks as the following:

"The history of specifications is not an approved branch of learning, but persons well informed about the industrial use of metals say that drastic inspection and specifications begin life as precautions, and usually follow mishaps. The precautions, based on anxiety, are, however, not abandoned when the real cause of the mischief is found not to be affected by them. Few people are able to understand why chemical analysis and tensile testing have grown so enormous; but more people know about absurdities which consign good material to the scrap heap. ....The aim of specification and inspection should be to reject nothing which is as good as anything accepted of the same kind." (To the last phrase might well be added "or any proved good material that has been accepted".)

All well so far. And to Brearley's remarks on the widespread utility of carbon steels in important machine parts, I can only echo approval, but with the added remark that American metallurgists (helped to their conclusion by widespread adoption of smart technical control in steel making) learned this before the present fracas began. We are apt to forget that our British friends did not believe in the general commercial control of grain size until long after we were all accepting it as commonplace — and that they likewise are still apparently in the "high alloy" era of 3300 and 2500 series steels.

So it is not surprising to find in this article the suggestion that "If tradition and non-metallurgical influences can be shaken off, then it appears that 3% of the alloying elements, divided as the competent steel maker decides, between nickel and chromium, is able (with a few doubtful exceptions) to do everything high tensile, nickel-chromium steels are asked to do. A similar remark applies to nickel steel; if the manganese and nickel together may amount to 3% in proportions chosen by the competent steel maker, then everything asked for from 3% nickel steels may be attained."

Right here Mr. Brearley and I part company — and I suspect most of my brothers in ⊕ will be on my side. Grossmann's mathematical concepts need not be used to point out the differences in hardenability between, say, ½% Cr, 2½% Ni, and 2½% Cr, ½% Ni steels, or between ¾% Mn, 2¼% Ni, and 2% Mn, 1% Ni steels. May I be out of town the day all these combinations — and others totalling 3% of alloy — come to the heat treat in the form of gears and shafts to be given the same quenching treatment!

The "competent steel maker" in such event will end up by selecting one narrow range of composition to meet his customer's requirements

— and there is a specification! Maybe Mr. Brearley means a steel maker who is competent to produce good steel, but *our* steel makers do more than make good steel — they tailor the steel to fit our needs, even beyond a close chemical specification. And not even a Johnny-come-lately in the alloy steel game who in peacetime only made fenceposts or the like would think of saying to his American customer, "Take it; it has 3% alloy and can be heat treated to meet your final requirements — never mind how it forges or machines, or what its Ac_3 is, or what you should quench it in. . . . ."

No doubt at all that the above is an absurd exaggeration of Brearley's thought, but it is nevertheless an appalling idea. Many of us have railed about the way our steel suppliers sometimes seemed to be banded together to force on us a wider chemical range on one element, or a higher extra for some detail — but they usually have been on the side of law and order as far as we consumers are concerned; they have gone far out of their way to create for us specialized steels of restricted range of chemistry and other characteristics, and to try to insure uniformity and reproducibility.

As I read over the above remarks I see that Mr. Brearley's suggestion made me realize how helpful our steel suppliers are — but I shall forget this the next time I choose to squabble with one of them about extras or something of the sort.

METALLURGICUS

Identification of Brinell Balls

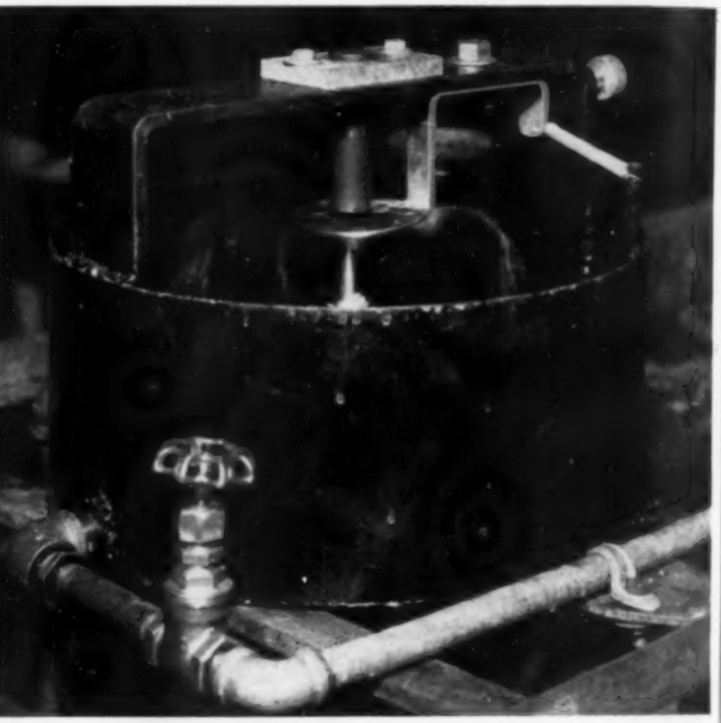
AT A LARGE PLANT the chief inspector recently suggested that some erratic hardness tests might possibly be due to tungsten carbide balls in the Brinell machine rather than ordinary steel balls. The following test was devised, using a spot test acid solution:

The solution consisted of two parts by volume of H_2O, two parts HNO_3, and one part H_3PO_4. One drop of this solution on the steel balls causes violent reaction, whereas one drop on the tungsten carbide balls causes only slight reaction. The reaction is instantaneous. After the test is made the balls are washed free from acid and are ready for use.

Does anyone know of alternative tests, or methods of distinguishing between quench hardened balls and surface-peened steel balls?

Technique for Spray Quench

STANDARD PRACTICE in the heat treating departments of Ingersoll-Rand Co. with respect to spray quenches is to keep the liquid running in these almost up to the time of quenching, then shut off the spray, blow off the excess liquid and when the hot piece is in place re-start the spray. We also keep the valve as close to the spray as possible. This practice insures that the initial liquid hitting the piece is of storage tank temperature and as free as possible from a mixture



of brine and air, which is produced where the liquid has a long way to travel — and is, of course, materially lower in quenching speed.

We have adopted this same practice with regard to our Jominy end-quench fixture, as will be noted from the photograph. The water is allowed to run all the time and hit against the baffle, which is subjected to spring pressure and held in place by a trigger. When the specimen is placed in position the trigger attached to the knob at the far side of the yoke is pulled, the baffle flips to one side, and the water jet then approximates what we feel is high grade quenching practice.

The upright nozzle pipe is screwed directly into an elbow which is welded fast to the bottom of the small tank. (FRANK MILLER, Research Section, and BEN. F. SHEPHERD, Chief Metallurgist, Ingersoll-Rand Co.)

Identification of Negatives

It is usually necessary in taking a series of photomicrographs to keep a careful check on the subject exposed and then to scratch some identifying mark on each plate before it is developed. This is time consuming, and also one may accidentally scratch an area which is wanted for the finished print.

In our laboratory we have all our plate-holders numbered on the outside, and a corresponding number of small notches cut in the thin wooden ledge of the rack on which the plate rests inside of the holder. Thus the number of the plate-holder appears on the finished plate as a series of small projections of the exposed area into the clear margin on the end of the negative. It is then only necessary, when making a series of photomicrographs, to record the number of the plate-holder on which each subject is taken, and then to match these up with the code marks as they appear on the finished negative. (George L. Parrott, Metallographer, Revere Copper & Brass)

Hard Surfacing by "Two-Tone" Welding

Rebuilding of worn surfaces on power shovels, cement mill equipment, rolling mill wobblers, and farming equipment, is an old story, and the supply companies have promoted quite a line of special electrodes for such hard surfacing. The process is equally good for repairs on worn tracks, rollers and sprockets on crawler-type tractors. The total area for a complete job on such a machine is much larger than generally supposed, amounting to 40 sq.ft. on ordinary-sized jobs, and requiring 75 to 100 man and machine-hours for re-surfacing by welding. To cut this time the "two-tone" process has been developed.

This consists of welding in the conventional manner with ¼-in. E-6010 electrode (mild steel, reverse polarity). Amperage is increased 30%, which would be expected to melt a large pool of metal. However the welder, with his other hand, holds a ⅜-in. bare rod of hard facing alloy, so its end is adjacent to the arc; the excess heat merely melts this auxiliary filler rod, in equal quantities with the electrode, which itself is being consumed 30 to 50% faster than normal. Progress of the pool along the surface is more rapid, so the parent metal is not abnormally heated.

Soft steel electrode and alloy filler rod mix thoroughly, and the result is a high carbon, low alloy steel of small grain size, high hardness, and good resistance to shock, spalling, or edge impact. Properties and hardness are variable; Rockwell C-33 may be had by adding high carbon bare rod; C-55 from molybdenum cast iron, and an intermediate value from plain cast iron filler rods. Speed of the work is doubled, which has been a life saver on some emergency repairs. (Joseph A. Cunningham, Welding Engineer, Arcway Equipment Co.)

Beam Marks the Spot

When electrodes on a spot welder are separated full distance, the operator must guess at the exact point where they will close to make the spot weld. It is comparatively easy to rig up a pin-hole lamp which throws a tiny dot of light to this spot. This enables him to space the welds

evenly, and at the correct edge distance, thus making a stronger, more uniform seam. (A. B. White, Research Engineer, Westinghouse Electric & Mfg. Co.)

Spotting Cobalt High Speed

An inquiry from a Canadian ASMember for a quick and easy way to distinguish standard tungsten high speed steel from the varieties containing cobalt brought the following responses:

1. There is no real difference in the spark from a grinding wheel. It is easy to distinguish them from the appearance of the scale on the

original bar, or if the bar is scale-free, from the appearance of heat treated tools. Surface of 18-4-1 is then very smooth and bluish in color. In contrast to this the cobalt high speed steel (specifically, 14-4-2-4) lacks this smoothness, the surface scale having a rough appearance that is characteristic of the grade. This difference holds true even of hardened sections which have not had the surface removed before hardening. (A. J. SCHEID, Jr., Chief Metallurgist, Columbia Tool Steel Co.)

2. The separation of these two types of high speed steel is easily made by the simple expedient of placing several drops of concentrated hydrochloric acid on the surface, which need not be ground since if cobalt is present it will also exist at the very surface even when considerable hot rolled or annealed scale is present. After allowing the drop to react for 5 to 30 sec. the presence of cobalt can be detected by the appearance of a bluish color in the liquid. Regular tungsten high speed steels will not show this bluish color; they will only appear gray. The bluish color usually first makes its appearance near the periphery of the liquid drop. (GEORGE A. ROBERTS, Research Metallurgist, Vanadium-Alloys Steel Co.)

Dynamiting Frozen Drill Ends

BROKEN DRILLS, stuck deep down in holes, or even broken off flush with the surface, can become the costliest of machine shop accidents. At Ohio Crankshaft Co., for example, from 100 to 125 such breakages occur monthly, and if the crankshafts could not be salvaged this would represent a loss of $30,000 to $40,000. Usual efforts to free them only freeze them tighter, if that were possible! About 10 years ago I originated the very effective method of blasting them loose with dynamite.

When the drill is broken off below the surface, the shaft is taken into a clearing, placed on a skid, and a thimbleful of crumbled powder from a dynamite stick pushed into the blind hole, using a small rough and round stick, and tamped slightly — all as shown in the attached photograph. No more than a thimbleful is ever used. Generally, the amount is considerably less depending upon the size of the hole and the set of the drill. Practice has shown the proper quantity of powder to use for certain conditions. Put in less powder, rather than too much.

A 6-in. fuse is next inserted into a close-fitting, shoulder-free cap, dropped into the oil hole on top the charge, and a heavy plank or timber laid over the bearing surface to check the flight of the drill fragment as it is blown free.

Drills are freed by the pressure of the rapidly expanding gases which follow the drill flutes to the bottom of the hole and there reverse in direction to drive the piece back out.

Occasionally a drill breaks off flush with the bearing surface. To blow this necessitates building a putty dam 1½ in. high above the hole. Into the dam is tamped a little powder, the dynamite cap and its fuse, and the detonation either blows out the drill or enough of it so that the next charge can be inserted directly into the hole, thus finishing the job.

To test results, the dynamiter uses a common brace and bit. When the bit is inserted in the hole it reveals by difficulty in turning or by a clicking noise that the drill is still within. If it turns easily and backs out chips, the drill has been blown free.

There is no evidence of harm to thousands of crankshafts which have been salvaged and have gone on to complete long and satisfactory service records. Needless to say, each such piece was closely inspected and magnafluxed to prove it sound. (NELS SORENSON, Superintendent of Automotive Crankshaft Division, Ohio Crankshaft Co.)

Magnesium — either molten or at heat treatment temperature — is very reactive and this (together with high solidification shrinkage) is responsible for most of the foundry defects. Knowing their causes, appropriate steps can be taken to get them under control

Causes and Cures of Defects in Magnesium Sand Castings

By Roy B. McCauley, Jr., and L. F. Mondolfo
Instructors in Metallurgy
Illinois Institute of Technology
Chicago

A DISHEARTENING amount of scrap has been produced by magnesium foundries — for several understandable causes. Chief of these is the relative youth of the art, and the 100-fold expansion since 1939. Another difficulty, more inherent, is the oxidizability of the metal. Still another important cause, which is often forgotten, is the use of magnesium castings predominantly for aeronautical purposes, for which requirements are very high and inspections consequently very strict. For these reasons the percentage of scrap in a magnesium sand foundry very seldom falls below 15% and it is more likely to be around 25%, measured as the percentage of defective castings. (Gates and risers, sometimes considered as "scrap", are likely to be from 60 to 80% of the metal poured.)

In the average plant there will always be a certain percentage of defectives, born from so many different causes that, although theoretically it would be possible to avoid it, in normal operations perfection is not attainable. This per-

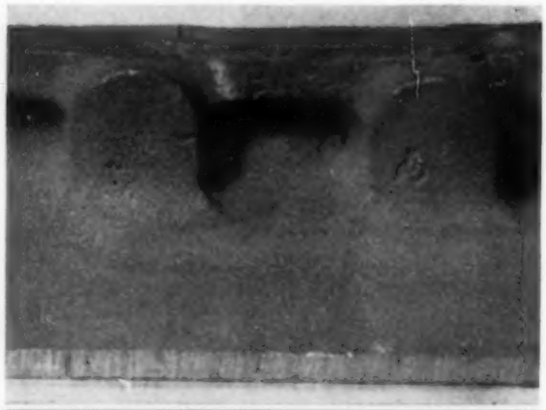
Defects From Melting, Pouring, Casting

Oxide inclusions	Defective fluxing, skimming, pouring, gating.
Flux inclusions	Defective pouring; use of improper flux, and improper use of flux.
Oxide skins	Lack of protective atmosphere in the mold; turbulence due to improper gating.
Blows	Dirty or wet sand; wet chills; defective venting or baking of the cores; turbulence in pouring; clay balls; too much sulphur in the sand; coal or other contaminants in the sand.
Metallic impurities in the alloy	Contamination in charging; lack of refining treatment.
Large grain size	Poor superheating practice.
Shrinks and draws	Defective gating or feeding; too high or wrong pouring temperature.
Cracks	Hard cores, uneven cooling, shake out too early.

Defects From Heat Treatment

Lack of solution	Too short time of treatment; too low temperature of treatment.
Eutectic melting	Too high temperature of treatment; too rapid rise to heat treating temperature.
High temperature deterioration	Water in the furnace; lack of protective atmosphere.
Warpage	Internal tensions; improper loading or poor support in furnace.
Grain growth	Cold straightening, or other causes of excessive residual stresses occurring prior to heat treatment.

Fig. 1 — Oxide Inclusions in a Casting. Natural size



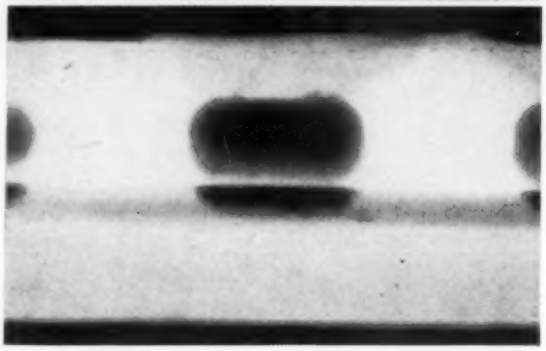


Fig. 2 — Radiogram of Same Casting; Spots Are Oxide Inclusions in Web Between Bosses

centage of scrap, caused more by human errors than defective practice, runs about 10% in good magnesium foundries, and this figure may be considered a practical minimum.

In addition to that scrap, every foundry — even the best managed — at some time or other has epidemics of some defect, caused by some voluntary or involuntary deviation from established practice, which will temporarily raise the percentage of scrap sometimes up to 100% until the cause is found and corrected. These epidemics are probably unavoidable; it is the early or late detection and correction of them which make the difference between a good and a poor foundry.

This paper, and its sequel, will attempt to illustrate most of the common defects encountered in magnesium castings, list their causes, and give hints as to ways to correct them. The defects with their causes are tabulated on page 905 for easy consultation; further on they are discussed and illustrated in greater detail. The list contains only those defects which are peculiar to magnesium castings or which, although common also to other metals, have a distinctive appearance in magnesium castings. Defects like misruns, core shifts, drops, off-size castings, and so on, which do not require any particular knowledge to be diagnosed, are not listed. Since most of the magnesium castings are used in the heat treated condition, defects caused by heat treatment are also listed and illustrated.

Oxide inclusions usually are easily detected by visual examination, because they tend to be at the surface. Figure 1 shows several pieces of oxide, entrapped in a casting. X-rays do not reveal oxide inclusions particularly well, because magnesium oxide has almost the same coefficient of absorption as the metal itself. X-ray detection is therefore based on the fact that usually oxide is not so closely packed as the metal, and therefore shows as a darker area (Fig. 2).

In spite of protective fluxes, it is impossible to avoid completely the oxidation of molten magnesium. Stirring of the flux into the melt is intended to eliminate the oxide formed in preceding operations, and precipitate it to the bottom of the crucible in the form of salt-oxide mixture, heavier than the metal. After fluxing care should be taken to keep the metal always covered with flux to avoid further formation of oxide; also avoid agitating the metal, since oxide tends to settle at the bottom by itself, if the melt is quiet.

The mold should be poured without undue agitation, to prevent the oxide at the bottom from rising. The skin of oxide, which forms immediately upon exposure of the metal to the air, should never be broken. If pouring is properly done, the melt flows evenly into the mold, inside a tube of oxide, which forms immediately and does not break during the whole pouring. These are the ideal conditions for avoiding oxide inclusions; however, since it is almost impossible to obtain them, the gating is usually designed so as to entrap oxide which found its way in, before it reaches the casting itself.

Two methods are in common use: *(a)* The use of slot gates to slow down the flow of metal and avoid the entrance of large pieces of oxide into the mold, and *(b)* the use of screens to prevent coarse oxide particles from entering the casting.

Both methods are effective when properly used, so that one cannot lay down a steadfast rule when to use one or the other. Commonly they are used together in the same casting.

If the precautions outlined above are taken, oxide inclusions should be very easily eliminated.

Flux Inclusions — The fluxes used for magnesium alloys are highly hygroscopic. Flux, when entrapped in the casting, will therefore absorb moisture from the air, creating a corrosive condition around the spot. This corrosion does not stop, but under unfavorable conditions, as in a wet climate, may ruin the casting. For this

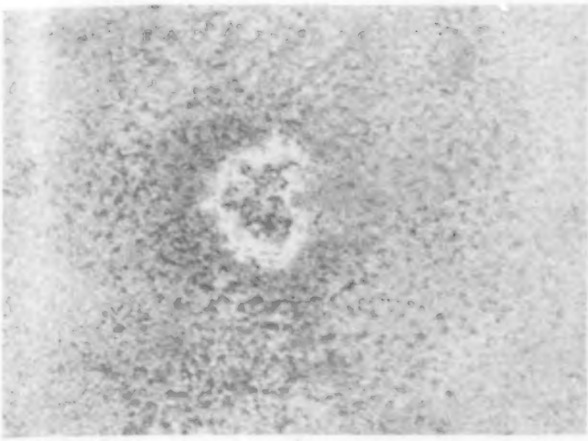


Fig. 3 — Corrosion Caused by a Flux Inclusion, After One Week of Standing in the Air

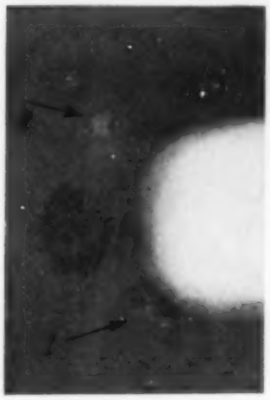


Fig. 4 (Right) — Radiogram of Flux Inclusions. Inclusion 1, loosely packed, is darker, inclusion 2, closely packed, is lighter than the surrounding material. Between the two is a zone of micro-shrinkage.

reason, when a flux inclusion is detected, the casting should be rejected.

Flux inclusions cannot ordinarily be found immediately after casting, because there is so very little to see. After standing — when corrosion has set in, creating the white-gray deposit of oxide — flux inclusions can be easily detected.

X-rays are not of very great help in locating this defect, since the fluxes have about the same absorption coefficient as the metal. The flux itself is usually denser than the metal and shows as a lighter zone — but, since it may be loosely packed, it may appear as a darker spot.

The best means of detection is visual examination. After a week in the air, corrosion has usually reached such an extent that it cannot be missed. To accelerate the action it is sometimes expedient to store the castings in a humidity room, in which the air is kept hot and moisture-saturated. This way the corrosion is accelerated and flux inclusions can be detected in 15 to 20 hr. after starting the test.

Most flux inclusions are caused by careless pouring. If the flux is not skimmed back from the ladle, or the crucible is jerked when pouring, there are good chances that flux will find its way into the mold. Another source of trouble is to pour *all* the metal in the crucible into the mold, without leaving a heel in the bottom, where the flux, heavier than the metal, has settled. In usual practice a layer of about 2 or 3 in. at the bottom of the crucible is a mixture of metal and flux.

The use of the wrong flux — that is, a flux which is too fluid — is another source of inclusions. This cause, which was one of the main problems which had to be solved early in the life of the magnesium industry, is now mostly eliminated, because the fluxes at present on the market tend on standing to become dry and lose fluidity.

Care in pouring is the best remedy for flux inclusions. If the flux is added to the crucible too short a time before pouring it does not thicken properly. Trained workers at the pouring stations are the best insurance against trouble.

Oxide skins are usually distinct from oxide inclusions both as to appearance and causes. Oxide *inclusions* appear as chunks of oxide, usually rounded, whereas oxide *skins* show as wrinkled surfaces. Figure 5 shows a typical occurrence, and Fig. 6 a more serious case. Best detection is by visual examination.

As already mentioned, molten magnesium is always covered by a film of oxide which protects the underlying metal. In normal conditions this film is very thin and no trouble to the foundryman. In special conditions — as when magnesium is poured at high temperature in a mold without any protection — the oxide film becomes very thick. If the gating is so arranged that this film is allowed to concentrate at some important surface, a defective casting is produced. If, however, the gating is arranged in such a way that the film will concentrate in a harmless spot, for instance in the gates or risers, the trouble is avoided. That may be possible with simple cast-

Fig. 5 (Left) — Oxide Skins in the Dark Wrinkled Zone
Fig. 6 (Right) — A Severe Accumulation of Oxide Skin

Fig. 7 — Inclusions of Mg_2Si (Dark); Rounded Lighter Particles Are Manganese, Light Network Is AlMgZn Constituent. 250 diameters, not etched

ings, but too difficult with complex castings. Therefore, rather than use a makeshift arrangement, it is better to eliminate the defect at the source. A reduced pouring temperature, when possible, and the use of a higher percentage of inhibitors in the sand will sometimes work. The best means however is the use of a sulphur dioxide atmosphere inside the mold, either by putting some sulphur in the gates before closing the mold or, better, by introducing sulphur dioxide gas into the mold a few minutes before pouring.

Metallic Impurities in the Alloy — The magnesium alloys mostly used for casting contain aluminum and zinc as main alloying elements; manganese is a minor addition to increase the corrosion resistance. Specifications allow a small amount of silicon to be present, usually not more than 0.30%. Copper, iron and nickel should be as low as possible, since even a small amount of any one of them will lower appreciably the corrosion resistance of the alloy.

Chemical or spectrographic analysis is commonly used for the detection of the impurities; sometimes also the microscope can be used to advantage as shown in Fig. 7, which shows inclusions of silicon as Mg_2Si.

The only way to avoid the presence of other harmful alloying metals is to avoid contamination, since once they are in the melt they are there to stay. Iron is in another condition. Its solubility in magnesium is so very limited, that little can be held completely. If the melt is allowed to stand for a sufficient time at a temperature at which it is quite fluid, practically all the iron which is in the melt, probably as crystals, settles to the bottom of the crucible. This is also a reason why all the metal in the crucible should not be poured into the mold.

Blows — This is one of the most common defects in sand castings. Blows cause at least one-third of the scrap in any sand foundry. Figure 8 shows the typical aspect of a blow in a thin casting.

Usually, blows are easily detected by visual examination. Even when a blow is not open, there are rough spots on the surface of the casting, as shown in Fig. 9. X-rays easily show them as rounded — even circular — black spots on the film. The dichromate etch, which is standard practice for magnesium castings, is also helpful in their detection, since after washing and drying the blow will be outlined by a darker brown ring, as shown in Fig. 10.

Blows are caused by gas bubbles. The origins of these gases are many; they may be simply a bubble of air entrapped during pouring,

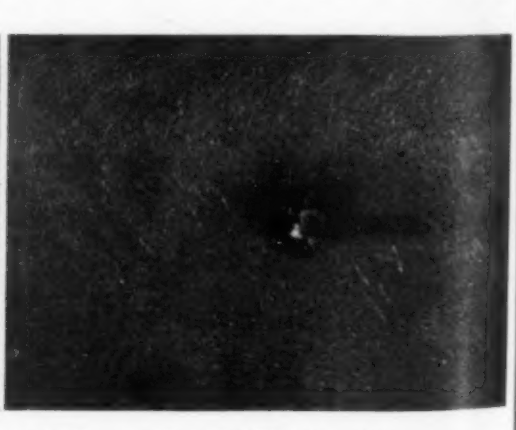


Fig. 8 (Left) — Fracture Showing Blow in a Thin Casting. Note smooth rounded surfaces inside the cavity. Fig. 9 (Center) — Rough Spots on the Surface of Casting, Indicating Presence of Blow. Fig. 10 (Right) — Same Casting as in Fig. 9, After the Dichromate Etch. The blow, outlined by the dark ring, has later been opened to show its size and position

which had no chance to escape; more often the gas may be formed by a reaction between the molten metal with a foreign substance in the mold. Rust, coal, paper, wood, and any organic substance reacts with magnesium, producing a gas. A small piece of any one of them in the sand is sufficient to cause a blow. Water, too, reacts with the metal to form hydrogen; a chill not perfectly dry or a wet spot in the mold is sufficient to cause blows. Another source is a clay ball; still another is an improperly baked or a wet core. Since the casting temperature for magnesium alloys is much lower than for iron or copper, there is much less evolution of gases from the cores. However, care should be taken to insure their proper venting and baking.

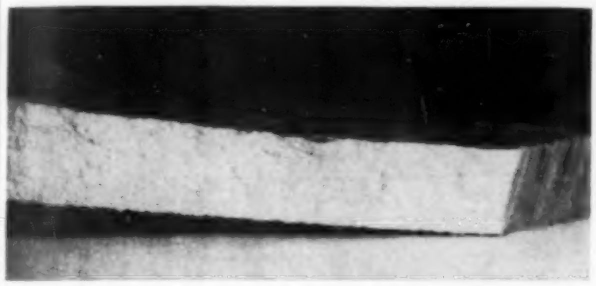


Fig. 11—Fracture of a Casting With a Good Structure; Natural Size

Inhibitors may also cause blows, either when they are absent or in too low a percentage, or when there is too much sulphur in a sand of low permeability, or when some "balled-up" boric acid is present.

No real difference exists between blows from all these causes, so that it is not possible to give a general remedy. When blows begin to show in an abnormal amount (a few castings containing blows will always be produced, no matter how careful the molding is) a study must determine their cause before any corrective steps can be taken. Once the cause is known, the remedy is usually obvious, although sometimes rather expensive — as in the case of contaminated sand.

Large Grain Size — The grain size in magnesium castings is usually so small that it cannot be seen without a microscope. A fracture test can be used to advantage, however; a smooth silky fracture, as shown in Fig. 11, reveals a fine grain size. Macro-etching can be used, too; if the grain size cannot be resolved, as in Fig. 12, the structure is good.

If the superheating is correct, little trouble should be encountered with the casting's structure. Remelting of gates and risers in the charge also helps refine the grain. When superheating

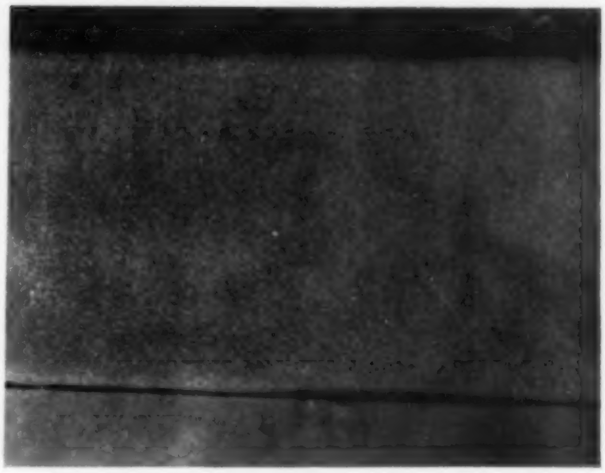


Fig. 12 — Macro-Etching of Good Casting, Twice Size; Etched With 10% Acetic Acid

is omitted or when, after superheating, the metal is cooled at a very slow rate, then large grain size can be expected in the finished castings.

Shrinks and Draws — After blows, these defects are the main source of rejected castings. Magnesium and its alloys have a high shrinkage coefficient which, coupled with a low eutectic content in the alloys, makes them very susceptible to these defects in spite of the foundryman's use of heavy and abundant risers.

Two types can be distinguished, macro-shrinkage and micro-shrinkage. Macro-shrinkage manifests itself as in other metals, with draws like the one shown in Fig. 13. Visual examination reveals it very easily; no other means are necessary.

Micro-shrinkage is different. Visual examination will not reveal it unless it is accompanied by macro-shrinkage, which seldom happens. The microscope — or, better, X-rays — will reveal it satisfactorily. Figures 14 and 15 show its appearance under the microscope and in a radiograph.

As already mentioned, high shrinkage coeffi-

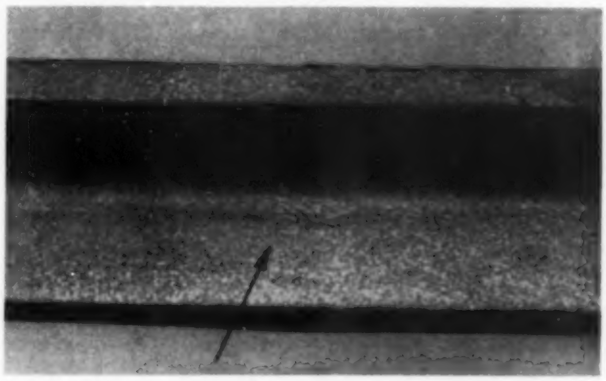


Fig. 13 — Macro-Shrinkage in the Form of a Depression Visible in the Center of the Casting

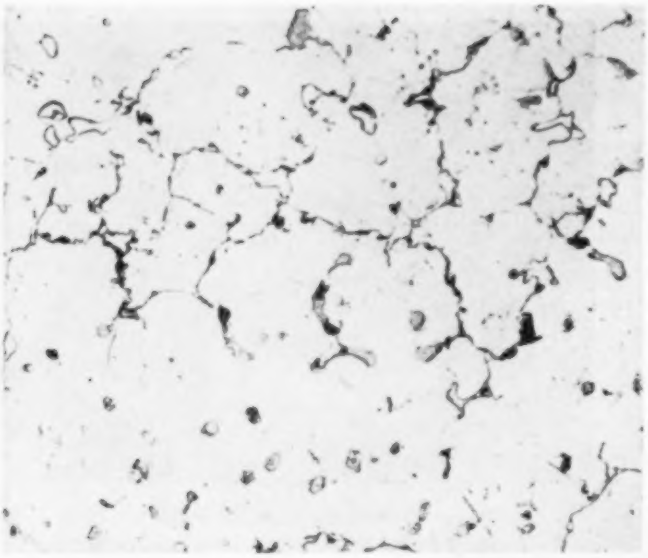


Fig. 14 — Micro-Shrinkage Has Caused the Voids (Black Lines) at the Grain Boundaries. Magnified 250 diameters; etched with 1% nital

Fig. 15 (Center) — Radiograph Showing Micro-Shrinkage as Darker, Ill-Defined Zones

cient and low eutectic content of the alloys are the causes. Since these properties cannot be changed, their amelioration must be sought in the gating and feeding. Also, the pouring temperature has its effect, since the higher the temperature the greater the total shrinkage. Sometimes this may not seem to hold true, since it may be found that by raising the pouring temperature some 50 to 100°, macro-shrinkage, as shown by draws, may disappear largely as an effect of better feeding by more liquid metal.

The proper placing of gates, risers, chills, is the only way to minimize these defects; we say *minimize* because, except in very special cases, it is impossible to eliminate them completely.

Cracks — Under this heading we will consider only cracks due to hot-shortness in the casting during cooling. (Cracks produced by accidental causes are not considered, since they are not casting or heat treatment defects.)

A distinction between the two is very easy. Cracks produced in the range of hot-shortness show a brownish-yellow surface, as can be seen in Fig. 16. Detection of cracks is also easy; in most cases they will open up in such a way that it will be impossible to miss them. The dichromate etch may also help, since it will outline the crack with a brown border, as in the case of blows. X-rays, too, can be effectively used when directed in the same general plane as the crack.

The main cause of hot cracks is to be found in non-yielding molds, so stiff that the casting cannot move as it shrinks in cooling. Green sand molds very seldom are so hard as to cause cracks; sand cores, baked too hard, are the main cause. Use of a softer or possibly a green sand core is the remedy.

Another source of hot-shortness cracks is the shake-out. If the casting is still in the hot-short range when it is shaken out from the mold, there is the probability that it will crack. The remedy for this difficulty is obvious.

The defects illustrated above may appear to be a formidable array. As a matter of fact, most of them are found in foundries casting nothing but the commoner metals — iron, steel, brass, aluminum. The peculiarities, physical and chemical, of magnesium will intensify the foundry troubles unless proper precautions are taken. Once this is done, however, a gratifyingly low percentage of rejects will result.

Fig. 16 — Hot-Short Crack Shown by the Darker Surface (Brownish-Yellow) in the Lighter Surface of a Magnesium Alloy Casting That Has Been Broken Cold for Inspection

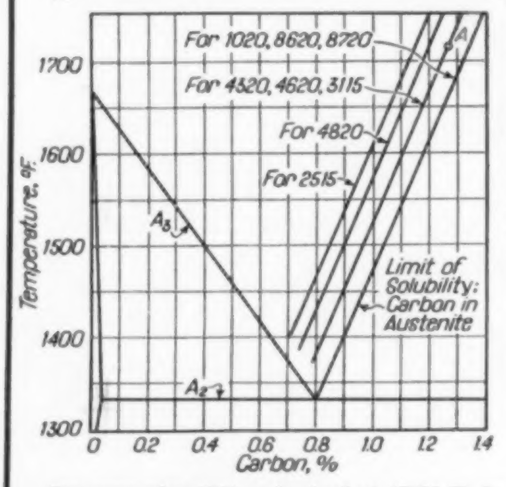
Carburizing and Diffusion Data

for eight common carburizing steels

By F. E. Harris

See *Metal Progress*, August, 1943, page 265

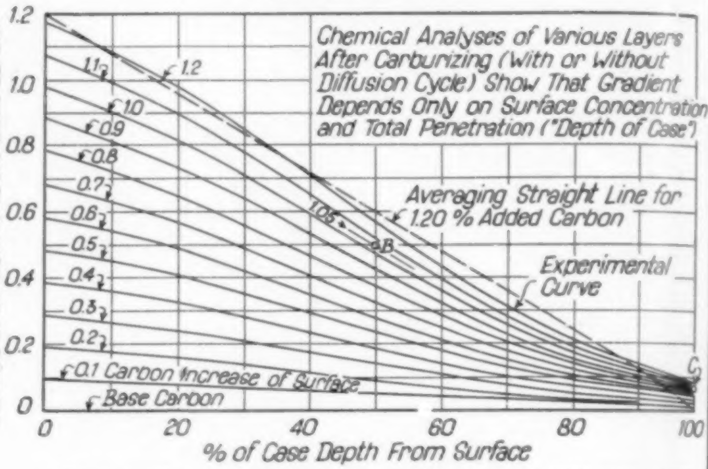
% C (Maximum Carbon) at Surface



For example: 4320 carburized at 1700° F., in an atmosphere that maintains saturated austenite at the surface, will have 1.25% max. surface carbon (Point A).

"% C Added" is 1.25 minus 0.20 = 1.05

Carbon Gradients



For example: % C added to the 4320 steel at half case depth is 0.50% (Point B); this is added to the carbon of the core ("base carbon"), so the actual analysis would be

0.50 + 0.20 = 0.70% carbon at half case depth

Area below experimental curve measures the carbon added to the entire case, and equals the area below the "averaging straight line". Intersection of latter with horizontal axis defines "case depth". Carbon analysis at this point in our example is

0.07 (Point C) + 0.20 (original carbon in steel) = 0.27%

Case Depths (C.D.) in Inches

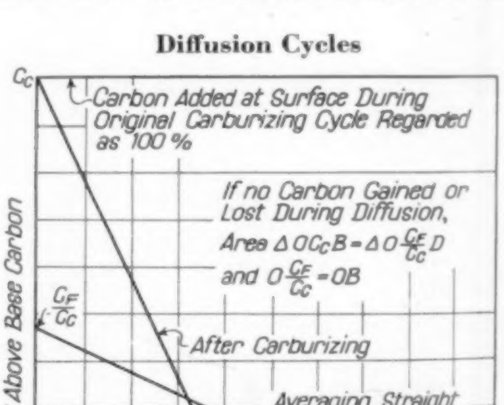
A function of temperature and time:

$$\text{C.D.} = K_{\text{temp.}} \sqrt{\text{Time}}$$

Time in Hr.	Temperature, °F. 1400	1450	1500	1550	1600	1650	1700	1750	1800	1850
1	0.008	0.010	0.012	0.015	0.018	0.021	0.025	0.029	0.034	0.040
2	0.011	0.014	0.017	0.021	0.025	0.030	0.035	0.041	0.048	0.056
3	0.014	0.017	0.021	0.025	0.031	0.037	0.043	0.051	0.059	0.069
4	0.016	0.020	0.024	0.029	0.035	0.042	0.050	0.059	0.069	0.079
5	0.018	0.022	0.027	0.033	0.040	0.047	0.056	0.066	0.077	0.089
6	0.019	0.024	0.030	0.036	0.043	0.052	0.061	0.072	0.084	0.097
7	0.021	0.026	0.032	0.039	0.047	0.056	0.066	0.078	0.091	0.105
8	0.022	0.028	0.034	0.041	0.050	0.060	0.071	0.083	0.097	0.112
9	0.024	0.029	0.036	0.044	0.053	0.063	0.075	0.088	0.103	0.119
10	0.025	0.031	0.038	0.046	0.056	0.067	0.079	0.093	0.108	0.126
11	0.026	0.033	0.040	0.048	0.059	0.070	0.083	0.097	0.113	0.132
12	0.027	0.034	0.042	0.051	0.061	0.073	0.087	0.102	0.119	0.138
13	0.028	0.035	0.043	0.053	0.064	0.076	0.090	0.106	0.123	0.143
14	0.029	0.037	0.045	0.055	0.066	0.079	0.094	0.110	0.128	0.149
15	0.031	0.039	0.047	0.057	0.068	0.082	0.097	0.114	0.133	0.154
16	0.032	0.039	0.048	0.059	0.071	0.084	0.100	0.117	0.137	0.159
17	0.033	0.040	0.050	0.060	0.073	0.087	0.103	0.121	0.141	0.164
18	0.033	0.042	0.051	0.062	0.075	0.090	0.106	0.125	0.145	0.169
19	0.034	0.043	0.053	0.064	0.077	0.092	0.109	0.128	0.149	0.173
20	0.035	0.044	0.054	0.066	0.079	0.094	0.112	0.131	0.153	0.178
21	0.036	0.045	0.055	0.067	0.081	0.097	0.114	0.134	0.157	0.182
22	0.037	0.046	0.056	0.069	0.083	0.099	0.117	0.138	0.161	0.186
23	0.038	0.047	0.058	0.070	0.085	0.101	0.120	0.141	0.164	0.190
24	0.039	0.048	0.059	0.072	0.086	0.103	0.122	0.144	0.168	0.195
25	0.039	0.049	0.060	0.073	0.088	0.106	0.125	0.147	0.171	0.199
26	0.040	0.050	0.061	0.075	0.090	0.108	0.127	0.150	0.175	0.203
27	0.041	0.051	0.063	0.076	0.092	0.110	0.130	0.153	0.178	0.206
28	0.042	0.052	0.064	0.078	0.094	0.112	0.132	0.155	0.181	0.210
29	0.042	0.053	0.065	0.079	0.095	0.114	0.134	0.158	0.185	0.214
30	0.043	0.054	0.066	0.080	0.097	0.116	0.137	0.161	0.188	0.217

For example: 4320 carburized at 1700° F. for 11 hr. at temperature would attain "case depth" of 0.083 in. If 0.100 in. were specified it would require 16 hr.

Diffusion Cycles



Example: Required carburizing and diffusion times at 1700° F. for 0.100-in. case in 4320, max. carbon at surface = 0.70% (approx. eutectoid)

T = total time = 16 hr. (from table at left)

C_D = % C increase over base carbon after diffusion = 0.70% minus 0.20% = 0.50

C_C = % C increase over base carbon after carburizing = 1.25 minus 0.20 = 1.05

$$\text{Carburizing time} = T \times \left(\frac{C_D}{C_C}\right)^2 = 16 \times \left(\frac{0.50}{1.05}\right)^2 = 3 \text{ hr. } 40 \text{ min.}$$

Diffusion time = 16 minus 3.64 = 12 hr. 20 min.

Ceramic Society Discusses Significance of Tests

LIKE recent meetings of other technical societies, the annual meeting of the American Ceramic Society in Pittsburgh, early in April, was surprisingly well attended. Interest centered in symposia and panel discussions, a type of meeting proving so successful and stimulating it seems destined to remain a fixture on the postwar gatherings of most technical groups.

Although the technical sessions of the several divisions of the Society covered little of direct concern to most metallurgists, there was a symposium on the significance of tests on refractory materials which was of considerable indirect interest because it indicated an attitude which might well be adopted in the testing of metals, especially in view of the ever-increasing amount of time and money which is being spent for this purpose.

In almost any field of technology there are a few tests which have outlived their usefulness and should therefore be drastically revised or even discarded; usually there are others which through long use have become endowed with a significance for which there is in fact little justification. Every test procedure should therefore be examined periodically and critically to determine the true significance and limits of usefulness of the results it yields.

The concept on which the test is based should likewise be studied, for all too often it is not well defined. In some instances it becomes more definite with accumulation of experience; in others it remains hazy. Some tests, such as determination of the melting temperature, yield the value of a physical constant of the material; others, for instance, the measurement of grain size, characterize not a single property but a combination of properties and prior treatment, a fact which need not impair the value of the test so long as it is clearly understood.

The discussion at this symposium emphasized what is probably equally true of tests on metals, that many tests are much more useful to the producer than to the consumer in that they provide the manufacturer with a criterion of the general quality of his product but yield little precise information of the kind most desired by the consumer. For example, comparative measurements of the rate of oxidation of metals in air may indicate to a producer the types of material most likely to resist scaling at elevated temperature, but they do not provide the user with a measure of the rate at which a certain piece of metal will scale in the particular atmosphere in which he is interested.

Some tests, including many acceptance tests, are largely empirical and have little value beyond providing a check on the apparent uniformity of a lot of material or on the degree to which one lot duplicates another — as inferred from this particular test. Kept within reasonable limits, such tests unquestionably have some use, but there is a danger that so many, and so many kinds, may get written into specifications that they become a serious and costly burden on both producer and consumer. As an illustration, extensive aging tests may require the manufacturer to store large quantities of material, pending completion of the test, and its acceptance by the consumer.

Tests also raise the question of how to choose samples which will be truly representative of the batch of material. Except for the rare test which is non-destructive, the number *(Cont. on p. 926)*

Reported by J. B. Austin
Research Laboratory, U. S. Steel Corp.
Kearny, N. J.

Redesign Increases Cyanide Pot Life

MOLTEN SALT BATHS have been for several years an important part of the equipment for heat treating at Perfection Gear Co. Molten cyanide, neutral salt baths, and carburizing salt are all three in use. Their primary functions are two-fold:

1. To produce a casehardened product.
2. To use the salt as a heating medium for hardening medium carbon steels.

A most acute problem was the extremely short life of the pots. This rarely exceeded 1200 heat hours and frequently was as short as 600 heat hours. (Temperatures of 1500 to 1600° F. were maintained during this service.)

The pots are cast, rectangular in shape, of a single size and design, being 40 in. long, 18 in. wide, and 18 in. deep, with a ⅝-in. section thickness and a rolled flange, made by the American Manganese Steel Division of the American Brake Shoe Co. The load is about 900 lb. of salt; the pots themselves weigh 500 lb.

The original furnace consisted of a rectangular heating chamber. The firing chamber was separated from the pot by a fireclay baffle, and a single oil-fired burner was used. (See Fig. 1.) To maintain a temperature of 1500 to 1600° F. in the molten salt, temperatures within the combustion chamber would run up to 2200° F. The result was that the flame from the burner struck the rear wall, was deflected, and hit the pot. Pots often failed at this end. There was also a tendency for the 20-in. span of baffle plate to bend of its own weight at high heat and cave in.

By J. H. Greenberg
Metallurgical Engineer
Perfection Gear Co., Harvey, Ill.

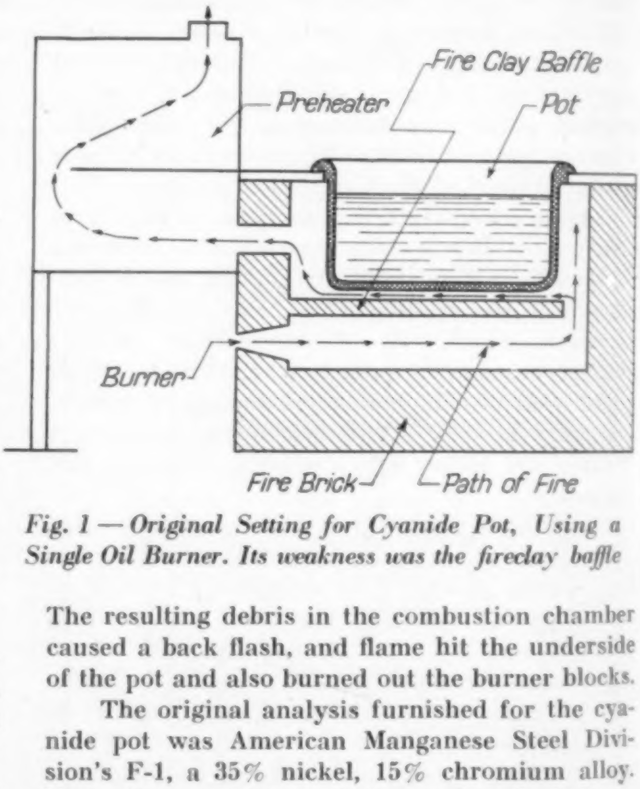


Fig. 1 — Original Setting for Cyanide Pot, Using a Single Oil Burner. Its weakness was the fireclay baffle

The resulting debris in the combustion chamber caused a back flash, and flame hit the underside of the pot and also burned out the burner blocks.

The original analysis furnished for the cyanide pot was American Manganese Steel Division's F-1, a 35% nickel, 15% chromium alloy. Under the conditions, existing as described above, this analysis did not resist the flame impingement and sulphur attack from the furnace gases.

In an attempt to remedy this situation, the alloy was changed to F-10, a 25% chromium, 12% nickel analysis. Here it was felt that the higher chromium content would resist better the flame and sulphur attack. The pot now resisted the flames on the outside but was readily attacked by the cyanide inside, with early failure resulting. The analysis was changed again to 25% chromium, 20% nickel, with the hope that the higher nickel would resist cyanide corrosion while the

high chromium resisted the flame. However, pot life remained extremely short, most of the failure coming from cyanide attack.

Finally the analysis of the pot was changed back to 35% nickel, 15% chromium, and the entire maintenance problem was attacked from a different angle.

The first step was to paint the outside of the pot with Ferritrol 19C. This product of the E. F. Houghton Co., when baked into the pot, helps protect the pot against flame attack and scaling. Pot life was thus increased about one-third beyond our experience with this alloy pot in previous years.

The next step was to change the oil-fired burner to a gas-fired type. A further increase in life was obtained.

Lastly, the inside of the furnace was redesigned with the following improvements:

1. Baffle plate was changed from fireclay slabs to Carbofrax brick.
2. A Carbofrax protecting wall was built at the far end of furnace to protect the pot against any deflected flame.
3. Baffle plates between flame and pot were supported by feather-edge bricks.

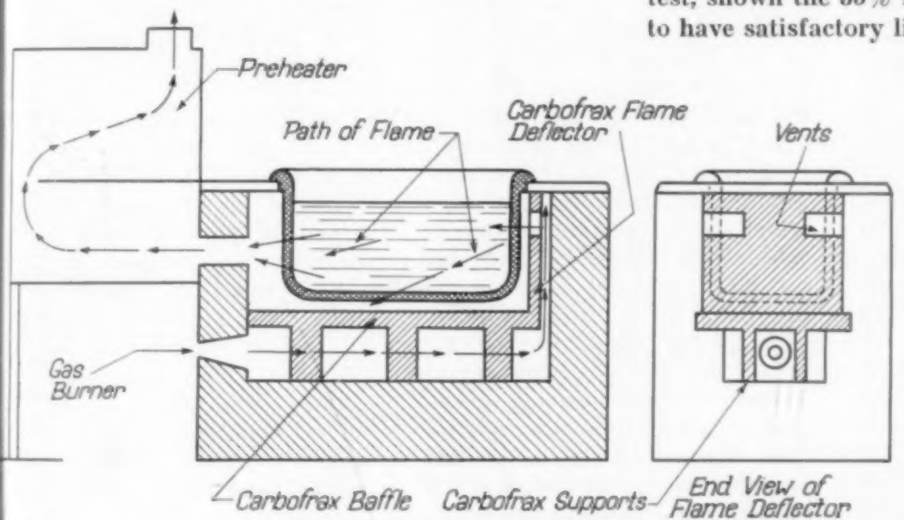


Fig. 2 — Improved Pot Furnace, Using Complete Baffles of Carbofrax Tile, Properly Supported

The result was the furnace sketched in Fig. 2. The complete installation is shown in Fig. 3. The resultant of the new ideas was a satisfactory pot life of 3000 to 4000 heat hours — in some cases it was as high as 4700 hr.

The 500% increase of life can be attributed to the following factors:

1. Correct pot analysis.
2. Gas instead of oil firing.
3. Ferritrol protective layer.
4. Furnace baffle redesign.

Where neutral salts are used, one additional precaution is taken. Every month the salt is removed and the pot is run with cyanide for several days. This has improved the normally short pot life in neutral salt to the point where it is almost as long as that of regular cyanide pots. Engineers of the alloy foundry have, by test, shown the 35% nickel, 15% chromium alloy to have satisfactory life in both types of salt.

It should be recognized, of course, that one of the most essential factors in a long life of any cast pot is the molding and gating, as well as the general foundry technique, and also the testing of the finished article. All of our pots are cast under controlled foundry conditions, are thoroughly X-rayed, and are pressure tested at 200 psi. before shipment.

Fig. 3 — One Unit of the Complete Revised Installation. Pot and setting in center, preheater hearth at left, quench tank in right foreground

"No one now has time to read," recently said a friend who has made good use of the published word, but was evidently that day behind in his work. Lots of books are being sold; and even though some are not read they serve a useful purpose if they are on your shelves ready to help when needed

Notes on Important Books

ON looking into the matter, the Editor finds to his chagrin that the April 1943 issue of *Metal Progress* was the last one to carry any notices of important new books. It is a circumstance requiring *(a)* an apology, *(b)* a reprimand, *(c)* a good resolution, and *(d)* amends. The first is implied in the above two sentences; *(b)* and *(c)* so far are matters in his conscience; *(d)* will now be attempted:

The spark plug, or booster, or detonator of this short train of thought was the reading of "Knotted String, an Autobiography of a Steel-Maker", by Harry Brearley.* While first published in 1941, it is new to me, and right glad I am to have found it, and so hasten to tell others of [illegible]. Brearley says himself that he grew up, rather than was brought up. It was in Ramsden's Yard in Sheffield, which, from his description, was the next thing to a slum. His "formal schooling" was almost non-existent; he was hardly in his 'teens when he became a cellar-lad in a crucible melting shop. Yet now, in describing an interview with South African mining officials interested in hollow drill steel, he is able to write such fine English as "The officials had credulous minds, ready to receive some metallurgical pill potent to purge away their troubles."

Brearley spent many years as a bottle washer in the chemical laboratory, assisting James Taylor, an analyst who lives again in words of shining praise. This was the beginning of the period in which he says he was "schooled". Finally becoming an analyst himself, he set about determining which of the routine operations were really necessary, and this not only enabled him to do his daily stint in a couple of hours (and started some ideas on the proper division of wealth created by technological advances, examined from various angles here and there throughout the book), but was the first manifestation of his lifelong urge to learn how to do things better and his deep distrust of dictums supported principally by ignorance, habit and prejudice. Nevertheless as a steelmaker Brearley acknowledges freely the help he had from the conscientious and skilled workman. This reliance on fact rather than tradition served him well, when as a young man he went to Russia to help with a steel plant, where none of the familiar Sheffield building materials or furnace charges were available, and where Lettish serfs had to be trained to melt the steel and heat treat the projectiles.

Returning he was asked to establish the Brown-Firth research laboratory, and his account of how he discovered what such a laboratory could and should do, and the kind of men required to do it, comprises one of the best chapters in the book. At this place, as everyone knows, was discovered stainless steel, a matter of no interest to his firm until an outside friend had proven that it could make most excellent cutlery. Brearley tells in tempered words of the disagreement that arose over the commercial development of his discovery, that led to his resignation. His later life, largely associated with the industrial application of this steel, is described rather sketchily in a chapter entitled "Working", a natural sequence to his earlier ones on "Being Schooled" and "Asking and Answering Questions".

Finally and happily comes a chapter on "Living". It comprises a series of short essays on various aspects of that art. The reader will not agree with all the thoughts there expressed, but will gather that Harry Brearley, after working hard at things that interested him, reached the stage of independence and affluence where he could live as he wanted to live before he had become so tired that life had no savor. Fortunate man! (E.E.T.)

*Published by Longmans, Green & Co., London and New York. 198 pages, 5¾x8¾ in. Price $2.50.

Steel Making

SEARCH through published issues of *Metal Progress* also fails to find mention of the Fifth Edition of Camp and Francis' "The Making, Shaping and Treating of Steel", originally issued (1919)

by the Bureau of Instruction of the Carnegie Steel Co. for its non-technical employees, but since then growing to the position of the authoritative book on conservative American practice.* The author of this thoroughly revised and greatly expanded volume modestly disclaims any "knowledge not available through other sources", which — even if true — does not detract from this encyclopaedic compilation of 1400 closely printed pages. Whereas the first three editions were limited to the practices of the Carnegie Steel Co., Mr. Francis has now drawn on the experience of other subsidiaries of the U. S. Steel Corp. This should make it sufficiently broad in scope; one would not easily find any commercial operations between the mining of the ore to the shipment of the mill product in plain or alloy steel that are not described — at least the Editor does not remember being disappointed in any of the frequent references he has made to the book in the three or four years it has been on his desk. The only criticism he might venture relates to the quality of the line drawings. (E.E.T.)

S-Curves

ANOTHER publication from United States Steel that excites admiration is "Atlas of Isothermal Transformation Diagrams". It is fitting that this be issued by the corporation's Research Laboratory, where this method of studying and plotting the transformation of steel was originated some 15 years ago. Numerous S-curves (so-called from their shape), TTT-curves (that is, time-temperature-transformation curves) or isothermal transformation diagrams have been published by various researchers in various places, but this is the first collection of them, published uniform in scale and nomenclature, and uniform in reliability. Diagrams for 47 heat treatable steels, including the most used carbon and standard alloy steels, are included; several have been studied in both coarse grain and fine grain. The value of the collection is enhanced by a preliminary description of the experimental work necessary to construct a diagram (and numerous blank charts invite the user to do so) and their utility in planning a heat treatment, whether a short annealing cycle, a drastic quench, or an austempering commonly known as a hot quench, interrupted quench or patenting operation. Last, but not least in these inflationary days, a copy may be had without charge by addressing on business stationery the Steel Corporation at P.O. Box 236, Pittsburgh.

*Carnegie-Illinois Steel Corp., Pittsburgh, Pa. Price $7.50.

Some Teaching Texts

PRINCIPLES OF PHYSICAL METALLURGY, by Frederick L. Coonan, U.S.N., 240 pages, 6x9 in., 190 figures. Harper & Bros., New York. Price $3.25.

GENERAL METALLOGRAPHY, by R. L. Dowdell, H. S. Jerabek, A. C. Forsyth and Carrie H. Green. 292 pages, John Wiley & Sons, New York. Price $3.25.

NON-FERROUS PRODUCTION METALLURGY, by John L. Bray. 430 pages, 92 figures, 6x9 in. John Wiley & Sons, New York. Price $4.00.

THE FIRST of the books mentioned above emphasizes the need for more precise terminology. Lt. Com. Coonan, who is associate professor of metallurgy at the U. S. Naval Academy, uses the term "Physical Metallurgy" (unhappily, I think) in the same sense Rosenhain did many years ago, that is, to include the treatment and properties of metals — once they had been won from their ores and refined and alloyed to a commercially pure state by the smelterman, steelmaker, mill or foundry metallurgist using the principles and art sometimes called "chemical metallurgy". He would also have done well to call this book "Elements" rather than principles, because it is quite elementary, and undoubtedly designed to meet the needs of a text for naval officers, very few of whom have any desire to get more than a smattering of a subject, apparently far less vital than, say, navigation. One is tempted to argue whether such men would be benefited by an equilibrium diagram of an alloy system containing a peritectic reaction; however, no two instructors agree on the correct content of a lecture course, as is quite evident from a comparison of the teaching texts that come forth in a continual stream. When such a large subject as "metallurgy for metal users" is compressed into 240 pages, it is obvious that matter included and matter excluded have required careful thought. Professor Coonan is to be complimented for a well balanced book (and Harper & Bros. for printing it in attractive form) and including in it some metallurgical topics now under active discussion. Likewise he is to be pardoned for his assured statements on some questionable matters; space rigidly prevents any desire to debate problems. (E.E.T.)

The book by Professor Dowdell and his associates at the University of Minnesota is frankly "for beginning students in metallography or physical metallurgy for engineers", and undoubtedly represents their ideas about what should be included in such a course. Any brief text is elaborated *ad lib* in the class room, so perhaps the reviewer gets a wrong slant when he considers the effectiveness of the book alone. When this is done, however, it appears that about 50 pages are occupied with miscellaneous data taken from the Metals Handbook, which every metallurgical student certainly should own. If this repetition had been avoided, space would have been available for important points all too briefly covered. A comparison with a

Books

fairly recent book by Yale-men Brick and Phillips on the "Structure and Properties of Alloys", intended to cover about the same ground, indicates that the latter profits from the omission of data better presented in the Handbook. P.S.: The reviewer is neither a Yale graduate nor a Gopher, and believes that the ordinary engineer (civil, mechanical, electrical) would profit more from metallurgy taught as an adjunct to a physical testing laboratory than from the viewpoint of the microscopist. (Metallurgicus)

The third book mentioned, by Professor Bray of Purdue University, is not so new but should even this late be mentioned because it approaches a completely satisfactory and up-to-date textbook on the concentration, smelting, and refining of the non-ferrous ores and metals. Several fuller texts on individual metals are available, but most of them date back to the last generation. Here it all is, in a nutshell; alternative methods of current importance are included, but for the historical development, or for obsolete or abandoned methods, the older books must be consulted. An especially praiseworthy feature of the book is its effective illustrations. Many simplified line engravings show the principal parts of furnaces, converters or electrolytic cells much more clearly than ordinary working drawings, which are often confused with minor details. All important parts are clearly labeled, so the student need never be in doubt as to the part it plays in the completed machine.
(Charles A. Nagler)

Aluminum

METALLOGRAPHY OF ALUMINUM ALLOYS, by Lucio F. Mondolfo, 351 pages, 482 figures. John Wiley & Sons, Inc. Price $4.50.

OWING to the extensive use of aluminum alloys, there is a real need for an up-to-date book on the metallography of these alloys. To meet this need, Dr. Mondolfo has written a book intended primarily for plant metallurgists who deal with the practical applications of metallography.

The contents of the book are divided into four parts. The first two parts which deal with equilibrium diagrams and polishing and etching cover their respective subjects fairly well although some features are overemphasized while others of importance have been mentioned very briefly or have been omitted. For example, the last two parts on commercial alloys and effect of fabricating do not cover these subjects as fully as the importance of these topics warrants.

The outstanding feature of the book is the complete and excellent collection of equilibrium diagrams. These diagrams will be found very useful for reference purposes. In discussing the subject of polishing, a rapid high speed-high pressure buffing method for preparing specimens is proposed which, however, does not appear practical for metallographic work on wrought alloys. The section on commercial alloys contains many micrographs showing typical structures of various types of alloys. This information would be much more useful had the commercial alloy designations or nominal compositions been given instead of grouping both cast and wrought alloys into four very general classes. Likewise, the discussions of the important alloys of the duralumin type, on heat treatment, and on corrosion do not cover these important fields of metallography to the extent they merit.

In general, the subject has been covered rather completely for metallurgists dealing with castings but not in sufficient detail for those working with wrought products. The book is well printed on good paper and is profusely illustrated, containing about 300 micrographs. It also contains a bibliography with approximately 1000 references. (F. Keller)

Metallurgical Data

METALS AND ALLOYS DATA BOOK, by Samuel L. Hoyt. 350 pages, 6¾x10 in., 60 figures, 340 tables. Reinhold Publishing Co., New York City. Price $4.75. (Extremely well printed on ledger paper)

MOST EVERY ENGINEER accumulates his own data book, and it includes some dope from his own experience, some clipped from magazines and trade literature, some copied from textbooks. Ordinarily such a book is quite personal and specialized, useful in its entirety only to the man who compiled it, and is supplementary, of course, to other working handbooks and mathematical tables. Only rarely does the accumulation extend to such lengths as Sam Hoyt's, and thus bulk large enough to attract a book publisher; to get it he borrowed heavily from publications of the ⊕, A.S.T.M., A.I.S.I., and the S.A.E. To those whose libraries are reasonably complete, therefore, this book will serve principally as a consolidated index. To those with less acquaintance with the professional literature, the book might be of more value if the source of each table or graph were noted. (The reviewer also confesses his partiality to graphical presentation, rather than to tabular, as used largely in this book, even though the former lends a false air of accuracy and finality to interpolated values or rounded curves.)

Much auxiliary information is necessary in order to utilize tabular data correctly — as pointed out by the author in the second paragraph of his preface. Likewise, the art and practice of metallurgy is changing at such a rate that some alloys are constantly being replaced with new combinations. Even the amount and accuracy of the information on tried-and-true metals grows daily. Hence the necessity for frequent revisions, and wariness in using old figures. Consequently

it seems that this book will be of most use as a recent and critical appraisal and selection of data currently available, published and unpublished, to one of our foremost metallurgists. (Martin Seyt)

Battelle Publications

THE INDUSTRIOUS STAFF at Battelle Memorial Institute has produced three notable metallurgical books within the last few years, to say nothing of an uncounted number of lesser works and reports. The first was the revision, and expansion to two volumes, of Bullens' old work "Steel and Its Heat Treatment", the only thing in American literature that approaches completeness. But that's an old story.

Next was a book on the Prevention of the Failure of Metals Under Repeated Stress (273 pages, 171 illustrations, 6x9 in., published by John Wiley & Sons, New York, at $2.75). While it appeared a couple of years ago, it still looks like a good book. One reason it is so good is that it takes the attitude, from first to last, that something can be done about fatigue, and then goes on to show what to do. Most publications on the subject emphasize the low stresses that cause failure; some go so far as to point out that nearly all our machinery and metal structures either fail from corrosion, from "fatigue" or from wear (and some believe that wear is a manifestation of fatigue), but few get over this defeatest attitude and hammer home the good news that a part with smooth surface free from stress raisers is sure to have superior endurance. The Battelle publication, sponsored by the National Research Council and the U. S. Navy's Bureau of Aeronautics, emphasizes the errors in design and fabrication that lead to failure in service. The reader cannot help but become aware of the dangerous effects of notches, keyways, splines, sharp fillets, oil holes and screw threads. Some 30 appendices elaborate the various factors which have an influence on the fatigue resistance of metals. By this unusual arrangement, any desired phase of the problem can be studied. While the book is intended for users of metals, and contains many valuable suggestions for design and fabrication, it should be in the hands of metallurgists and inspectors as well.
(John E. Stukel)

Most recent of the Battelle books is a report prepared by H. W. Gillett for the National Research Council on the Evaluation of Metallic Materials.★ It starts out to do for top flight designers — like the boys who scheme out crankshafts for 2000-hp. radial engines — what Gordon Williams tried to do for the scrub metallurgist in his little book "What Steel Shall I Use". It was circulated fairly widely in mimeographed type script before *Steel*, the Penton weekly, agreed to publish it serially and later as a reprint. Unfortunately its final embodiment is in such shoddy garb that its inner worth is likely to be overlooked.

Dr. Gillett's book is of course a much more learned treatise than Gordon Williams's; wide-awake metallurgists (as well as designers and production men) would do well to study it carefully and take its lessons to heart. It is easy to read, "fascinating" is a better word, what with its wealth of homely allusions, wisecracks, and its constant refusal to pull any punches. However in his desire to be technically accurate, the author frequently indulges in elaborate discussions of auxiliary aspects of the topic then under consideration, and the attentive designer, I fear, will get the idea that where there are so many "ifs, ands and buts" there must be only an exceedingly elusive and small kernel of fact. Or the nonmetallurgical mind may become confused and uncertain. Maybe some of the latter is a desirable alternate to a know-nothing, care-nothing attitude; however, the whole thing would gain from a more positive approach.

But then, maybe they tried it out on a sampling of their intended audience, and it clicked. In that case I'm acquainted with production men on an inferior plane of mentality! (E.E.T.)

★"An Engineering Approach to the Selection, Evaluation and Specification of Metallic Materials," by H. W. Gillett. Reprinted from *Steel;* 140 pages, 5½ by 8½ in., 48 figures, paper bound. Penton Publishing Co., Cleveland. Price $1.00.

All About Tungsten

TUNGSTEN, by K. C. Li and Chung Yu Wang, 325 pages, 6x9 in. American Chemical Society Monograph Series, published by Reinhold Publishing Corp., New York. Price $7.00.

IN 1911 K. C. Li had been commissioned to explore for tin in the southwestern part of China. One evening while stopping at a wayside inn in the province of Hunan he observed that the kitchen stove was constructed of blocks of wolframite, and upon inquiry learned that this rock came from an outcrop above the garden in the rear.

As a result of this discovery the Yu Hou Tungsten Mining Co. was organized and in December 1915 made the first shipment of tungsten ore from China, which shipment was consigned to the United States. The ore, as assayed by Ledoux and Co., proved to be the purest wolframite ever mined in any part of the world.

The foregoing paragraphs are abstracted from the "foreword" of the volume and comprise but part of the interesting and timely story of the metal, tungsten, which has during the present conflict assumed such pre-eminence as a strategic material.

The chapters in which the subject matter is ably presented deal with the history, geology, ore dressing, metallurgy, chemistry, analysis, industrial applications, substitutes, and the economics of

tungsten. Appended to each chapter is a well chosen and comprehensive bibliography, some of it chronological.

In reviewing a work of such uniform excellence it is difficult to select the outstanding features. As representative of the general high quality, however, might be cited the chapter on "The Geology of Tungsten". This presents the most important facts relating to the tungsten resources of the world, the types of ores and the disposition which has been made of them — including statistics for the year 1942 in many cases.

Several flow sheets appear in the pages devoted to ore dressing and the references upon which this chapter is based cover the period between 1901 and 1943.

"The metallurgy of tungsten", state the authors, "as it is today is largely empirical and is mainly based upon patents". At least the first part of this statement will be confirmed by anyone who is familiar with the commercial processes of tungsten extraction, purification and fabrication. Methods used in the production of the pure metal as well as of ferrotungsten and the sintered tungsten alloys are described in some detail and with commendable accuracy.

Chemistry and methods of analysis together form a valuable section, especially since the compounds of tungsten are numerous and often of an obscure nature.

Some twenty items are described under "Industrial Applications of Tungsten" and these appear to be properly rated as to present importance.

Of the authors, K. C. Li is chairman of the board of Wah Chang Trading Corp., New York. Chung Yu Wang, a University Medalist of Columbia University, is technical expert for the Ministry of Economic Affairs of China.

The authors as well as the American Chemical Society are to be complimented upon the preparation and publication of this much needed volume.

(W. P. Sykes)

First Flight

THE WRIGHT BROTHERS, A Biography Authorized by Orville Wright; by Fred C. Kelly. 340 pages, 16 full-page illustrations. Published by Harcourt, Brace & Co., New York. $3.50.

Now that a World War is about to be won by nations having unlimited numbers of fighting and bombing aircraft, weapons all but unknown in a bloody conflict 25 years ago, it is well to pay some attention to those two modest Americans who, in December 1903, were the first to fly in a powered machine. Being a newspaper man, the author understandably laments the almost total silence that greeted this truly epoch-making feat. Even he, himself, a reporter living within 15 miles of the Ohio cowpasture used by Orville and Wilbur Wright for their further development of the basic control mechanisms, refused to believe in flying, even though hundreds of passengers on the interurban had seen it being done. Eminent scientists also had proven repeatedly that a human being could not fly. Americans may well be mortified that the Wrights were discovered five years later by Europeans, and that their achievements were so persistently belittled by our own Smithsonian Institution that their original machine was sent to England for preservation. In this perhaps we followed the human trait of ignoring our really great men until after they are dead. Verily, the Wrights needed a press agent!

While not a technical book, this one will be of interest to many engineers, not alone those in the aviation industry. It allots much space to the early glider flights and the pioneering wind tunnel experiments that gave the Wrights the necessary information to design their successful machines. Likewise, the historic controversies with the Smithsonian and its Langley "Aerodrome", and with Glenn Curtiss and his "June Bug", are outlined with clarity. Unfortunately, Mr. Kelly has been unable to recreate Orville and Wilbur Wright as two personalities, not unique as Americans but extraordinary as inventors and applied scientists. Such pen pictures would be worthy companion pieces to the revealing portraits on page 276 snapped at Pau, France, in 1909, when the brothers were showing their flying machine to no less a personage than Edward VII of England.

Presses and Press Work

PLASTIC WORKING OF METALS AND NON-METALLIC MATERIALS IN PRESSES, by E. V. Crane. 540 pages, 5½x8¼ in., 430 illustrations. John Wiley & Sons, New York. Price $5.00.

THIS is a reprinting of the second edition (1939) of the well-known book "Plastic Working of Metals", with 80 pages added principally to extend its scope to plastics, the wonder child of the moment — all too small a space if the public prints can be used to appraise its importance. In these additional pages are also given some notes on wood, soft alloy or rubber tools devised by the aircraft industry for limited runs. Likewise the author has included metal powders and die castings. While there may be logic in associating these widely differing aspects of plasticity, the equipment for forming a sheet steel front fender, a paper Lilly cup, a lucite comb, and a carbide tool-nib are so different, and the requirements of the product so various, that the ordinary citizen would hardly recognize the kinship. The new book is printed with the wartime narrow margins, which gives the page a crowded look. The paper is also lighter in weight than in the second edition, but is amply opaque, and slicker, so it takes the halftone engravings even better. Some of these, by the way, are unduly small, and out of proportion to the size of the subject.

It is generally appreciated that the item of perishable tool costs is an important factor in manufacturing accounting. The possibility of savings offered by using molybdenum high speed steels, instead of tungsten types, is therefore worth consideration.

The savings are due first to the lower cost per pound of molybdenum steels, and second to their lower density. The latter results in more tools from an equivalent poundage.

The net savings effected naturally depend on tool performance. It is an established fact that, in a substantial majority of careful comparative tests made in the past, the performance of properly heat-treated molybdenum steels equaled, where it did not better, that of tungsten steels.

A consultation with your supplier should confirm these statements, but it would be a simple matter to check them in your own plant.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

MOLY

Climax Molybdenum Company

500 Fifth Avenue · New York City

Personals

Robert S. Archer, past president ⊕, formerly chief metallurgist of the Chicago District, Republic Steel Corp., has joined the Climax Molybdenum Co. as metallurgical assistant to the vice-president.

J. M. Watson, past president ⊕, who has been metallurgist with the Tank Automotive Center in Detroit, has returned to Washington to take charge of the Steel Division of the Metals and Minerals Branch of the Office of Civilian Requirements.

Honored by the American Chemical Society, Pittsburgh Section: Junius D. Edwards ⊕, assistant director of research, Aluminum Research Laboratories, Aluminum Co. of America, named recipient of the Pittsburgh Award for 1944 in recognition of his "distinguished service to chemistry".

V. N. Krivobok, ⊕ national trustee, formerly chief metallurgist of the Lockheed Aircraft Corp., Burbank, Calif., is now associated with the Development and Research Division of the International Nickel Co. at New York.

Promoted by American Steel & Wire Co.: H. H. Smith ⊕, formerly works metallurgist in Donora, Pa., to assistant manager, metallurgical department, Cleveland; R. A. Woodside ⊕, from division metallurgist to works metallurgist in Donora.

John T. Whiting ⊕ has resigned as director of the Steel Division, War Production Board, to return to his position as president of Alan Wood Steel Co., Conshohocken, Pa.

Arthur T. Clarage ⊕, president, Columbia Tool Steel Co., has been re-elected president of the Chicago Branch of National Metal Trades Association.

Albert M. Post ⊕, formerly associated with Edgar T. Ward's Sons Co., Cleveland, is now affiliated with the Bissett Steel Co. in a sales capacity.

George K. Dreher, past chairman, Milwaukee Chapter ⊕, has been promoted to vice-president in charge of manufacturing, Ampco Metal, Inc.

William A. Pennington ⊕, formerly with Mellon Institute, Pittsburgh, is now on the research staff of the Engineering Division, Carrier Corp., Syracuse, N. Y.

Elmer C. Cook ⊕, formerly sales manager of American Gas Furnace Co., is now associated with the J. E. vonMaur Co. of Columbus, Ohio, to assist in the selling of furnaces and industrial equipment in the Cleveland area.

Ralph K. Clifford ⊕, since 1940 vice-president in charge of operations, Continental Steel Corp., Kokomo, Ind., has now been elected vice-president and general manager.

Elected vice-presidents of Wickwire Spencer Steel Co.: R. T. Dunlap ⊕, formerly assistant to the president, and E. F. Early, formerly general superintendent at the Morgan Plant of Wickwire Spencer in Worcester, Mass.

Telechron Electric Timekeeper, Warren Telechron Co., Ashland, Mass.

Personals

Promoted by the Aluminum Co. of America: C. F. NAGEL, JR., from chief metallurgist of the Fabricating Division to chief metallurgist of the Aluminum Co., heading a newly created metallurgical division; T. W. BOSSERT, from assistant chief metallurgist to chief metallurgist of the Fabricating Division; C. L. DUNHAM, to chief metallurgist of the Reduction Division; H. J. ROWE, from manager of the general technical laboratory in the Castings Division, to chief metallurgist of the Castings Division.

ROGER F. WAINDLE, formerly chief of tank and automotive production for the War Department, Chicago Ordnance District, has been released to the Alloy Casting Co., Champaign, Ill., to become general manager and chief engineer.

ORLO E. BROWN, formerly chief metallurgist of Factory A (Vega Division), Lockheed Aircraft Corp., is now with Virginia-Lincoln Corp. of Marion, Va.

Promoted by Minneapolis-Honeywell Regulator Co.: KENTNER L. WILSON, from industrial manager of the Brown Division at Cleveland to branch manager of the Company's Detroit office; AL J. McCULLOUGH and JACK E. MACCONVILLE, placed in joint charge of industrial instrument sales for the Brown Instrument Division in Cleveland; D. J. PETERSON, from manager of the Detroit branch to charge of the Heating Control Division of the entire Cleveland zone.

GORHAM W. WOODS, formerly with Hughes Tool Co., Houston, Texas, and recently process engineer for Dickson Gun Plant, Houston, has been employed by Una Welding, Inc., Cleveland, as director of metallurgical research.

FREDERICK A. SCOTTON is now in the metallurgical division of Allison Division, General Motors Corp., Indianapolis, Ind.

W. E. KINGSTON, formerly chief metallurgist, Sylvania Electric Products, Inc., is now supervisor of metallurgical research and development engineering of all the company's plants, centralized at Sylvania Center, Bayside, L. I., N. Y.

CAPT. R. K. WELLS has been ordered to duty at U. S. Naval Dry Docks, San Pedro, Calif.

Elected by the Wire Association at its annual meeting: President — D. D. BUCHANAN, manager of operations, Union Drawn Steel Division, Republic Steel Corp.; vice-president — R. M. HUSSEY, superintendent wire department, Jones & Laughlin Steel Corp.; vice-president, Non-Ferrous Division — E. W. GUNDSTROM, assistant plant manager, Rome Cable Co.; executive secretary — R. E. BROWN, publisher *Wire & Wire Products;* new directors — KENNETH H. DAVIS, president, K. H. Davis Wire & Cable Co., and FLINT C. ELDER, special research engineer, American Steel & Wire Co.

DAVID A. COLEMAN has been elected vice-president of the Lake Shore Tool Works, Inc., Chicago.

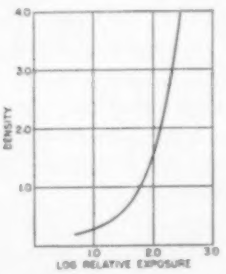
Q *Which x-ray film for*

1. Aluminum and Magnesium at low voltages?... and

2. Million-volt radiography of thick steel?

A *Kodak's Type "A"*

Kodak Industrial X-ray Film, TYPE A, is first choice for the examination of light alloys at lower voltages, and for the million-volt radiography of heavier steel parts, because of its fine grain and high contrast. Type A is similar in its characteristics to Type M Film—its grain is not quite as fine, but its speed, approximately three times that of Type M, makes it more widely usable.



Characteristic Curve, Kodak Industrial X-ray Film, Type A, with direct x-ray exposure. Development: 5 minutes, at 68° F, in Kodalk X-ray Developer.

Kodak Provides the 4 Types of Film Needed in Industrial Radiography

In addition to TYPE A . . .

Kodak Industrial X-ray Film, Type F
. . . primarily for the radiography, with calcium tungstate screens, of heavy steel parts.

Kodak Industrial X-ray Film, Type K
. . . primarily for gamma radiography, with lead-foil screens, of heavy steel parts . . . or lighter parts at low x-ray voltages.

Kodak Industrial X-ray Film, Type M
. . . "made to order" for higher voltages, light alloys, and critical inspection.

EASTMAN KODAK COMPANY
X-ray Division, Rochester 4, N. Y.

Mg Alloys

(Continued from page 900)

(f) Powdery coatings may sometimes remain after initial cleaning in chromic acid to remove oxides. If this occurs, it is necessary to neutralize the surface by returning the part to the alkaline cleaning operation or dipping the part in dilute NaOH and then rinsing before proceeding to the HF treatment.

2. **Failure to Coat.**

(a) The pH of the dichromate bath may be too high (not sufficiently acid). The pH range should be 4.2 to 5.5.

(b) The dichromate concentration in the bath may be too low. The dichromate must not be allowed to fall below 6% by weight.

(c) Oily matter may not have been properly removed. This is usually indicated by a spotted coating, with some areas coated and others not. Oily matter may also be present as a film on fluoride or dichromate solutions, whereupon even properly degreased parts will be contaminated during immersion or removal by this oily matter.

(d) The fluoride treatment may have been omitted. The absence of a MgF_2 coating on the metal will result in no coating in the dichromate bath.

(e) The part may be of "M" alloy. This treatment is not suitable for this alloy. Use one of the other treatments recommended for Mg-Mn alloys.

(f) Improper rinsing may have occurred after the hydrofluoric acid dip. If the concentration of HF in the sodium dichromate solution exceeds 0.3%, no coating will be formed and the bath must be discarded. Streaked coatings will be observed before this point is reached.

Sealed Chrome-Pickle Treatment

(Dow No. 10; Specification AN-M-12, Type II)

This treatment is most suitable for wrought alloys. If castings are to be treated, the parts must be given a preliminary treatment in hydrofluoric acid as described under the dichromate treatment, or pickled in sulphuric or nitric-sulphuric acid to remove 0.002 in. off the surface.

The sealed chrome-pickle treatment consists essentially of two steps applied as follows after proper oil and grease removal:

Step 1. Chrome-pickle as previously described.

Step 2. Boil parts for 30 min. in a bath containing 10 to 15% of sodium dichromate to seal the chrome-pickle coating. This operation is followed by a rinse in cold running water and then by a dip in hot water to facilitate drying.

CaF_2 or MgF_2 may be added to the dichromate bath. A slight improvement in corrosion resistance will result, but the treatment time should not be shortened.

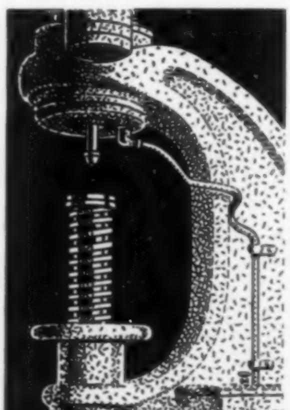
Operational difficulties which might arise in the application of this treatment are described under the chrome-pickle and dichromate treatments.

Significance of Tests

(Cont. from p. 911) of samples to be taken and the sampling procedure are likely to be matters for debate. If a large number of samples must be tested, an appreciable fraction of each lot may be destroyed, and yet fail to show the extreme limits of variation of quality of the lot. Recent advances in the adolescent science of quality control are, however, doing much to put sampling on a more objective and certain basis, though much remains to be done.

In the light of these discussions one would be justified in likening tests to a set of tools. They should never be taken for granted, but should be well cared for, sharpened occasionally and examined periodically for the appearance of rust. Moreover, it is desirable to stifle the collector's instinct and be willing to discard an instrument which has outlived its usefulness, even though it still is shiny, and be cautious about adding a new one, no matter how bright or streamlined it may seem to be.....

At a general session, Major Albert J. Stowe pleaded for more vigilance against careless talk — whether by the public, Armed Forces or the Government. As an example of the speed with which information is transmitted, he cited a recent German broadcast in which it was stated, correctly as it turned out, that a sentry at a certain post was at that moment asleep. He had been observed, the news transmitted to Germany and there fitted into the broadcast, all within an hour or so. "We are the most talkative nation on the face of the earth — a nation which values its free speech, a nation which never had to put a curb on its tongue, which has never had to suspect its neighbors or question its friends." Yet much damage has already resulted, and the anxious days ahead are no time to relax vigilance.



Metal Powders

(Continued from page 887) increases with decrea in a particle size, and this can be anticipated to true for metal powders. Incombustible impuriti such as oxides, will reduce flammability, but sm proportions will probably have little effect. Th if the relative flammability of a powder is 65% that is, 65% inert dust mixed with the powder order to prevent ignition — 10% incombustib impurities can do little toward preventing it.

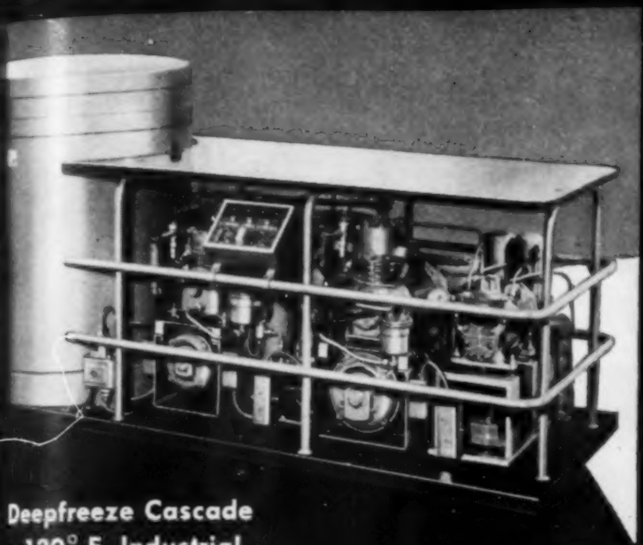
Pressure Generated — The table also gives da on the pressures generated with controlled dispe sions of powders. Maximum pressure and ma mum rate of pressure rise for a given powder a to be expected at or close to the concentration th will consume all oxygen in the air. This stat ments assumes that the powder is uniformly di persed in air and is completely burned. *Absolu* values of pressure will depend on the quantity heat liberated per unit volume, as the pressu from metal dust explosions is due almost entire to heating and resultant expansion of the gas rather than to the formation of gas.

After an explosion in a tight container is co pleted and the residual gases are cooled, the will be a partial vacuum in the container. Thu in any explosion of metal dust the surroundi walls will be subjected to bursting pressure fir and if they do not fail, a pressure tending to c lapse them will follow. If "pressure releases" a installed and function, they will tend to lower t bursting pressure.

Some out-of-line results noted in the ta may be due to the formation of sub-oxides or o nitride — as many of the metals can. Of cou such reactions affect the anticipated generation heat. This may also explain the fact that co puted temperatures and pressures for metal- explosions are all above the results found in th experiments. In very large explosions such th retical maximum pressures can be exceeded by phenomenon known as "pressure piling"; effect of this has been studied in gas explosio and there is no reason to doubt its probability dust explosions when the volume and configu tion of the space are such as to induce it.

Magnesium and its alloys have high fla mability, pressure and rates of pressure rise, b their ignition temperatures are higher than th of some other metals that may be considered l hazardous. Stamped aluminum ranks a little bel magnesium, and atomized aluminum is definit below the stamped variety. Titanium ranks o slightly below aluminum.

(Continued on page 932)



Deepfreeze Cascade
−120° F. Industrial
Chilling Machine

Does This Answer Your Questions About The NEW Deepfreeze Process for Cold Treating Metals?

What Is the Deepfreeze Process?

It is the application of Deepfreeze Industrial Chilling Machines for the hardening, seasoning, shrinking and testing of metals by freezing at temperatures down to −120° F. This process involves a new principle of refrigeration, which permits faster, more efficient heat removal.

What Is the New Deepfreeze Refrigeration Principle?

100% primary freezing surface is provided in the Deepfreeze machine, which has been designed with a double-wall chilling cylinder, through which a refrigerant circulates. It is possible to reach temperatures as low as −120° F. with the Deepfreeze machine, which has the capacity to remove 1,000 B.T.U.'s per hour, at −120° F., when the work is immersed in a convection fluid

How Does the Deepfreeze Process Compare With the Dry Ice Method?

Dry ice temperature of −109° F. delivers a maximum chill of only −91° F. working efficiency, as compared with a constant 24 hour temperature of −120° F. provided by Deepfreeze. The cost for removing 1,000 B.T.U.'s per hour for a 24-hour day, over the period of one year, with dry ice is approximately $3,000; the current consumption of the Deepfreeze machine over the same period of time costs $175.

What Is the Cost of Deepfreeze?

The initial cost of only $2,500 for the standard Cascade −120° F. Industrial Chilling Machine is quickly recovered in reduced production costs. One manufacturer saved from $3,000 to $4,000 per month in shrink-fit application. Gage manufacturers save time and money by seasoning gages to prevent change in finished size. The increased tool life resulting from cold treating reduces down-time and lowers tool cost.

Is the Deepfreeze Process Still in the Experimental Stage?

No! Hundreds of Deepfreeze Industrial Chilling Machines are now being used in actual production. Deepfreeze equipment has been tested and proven highly valuable in such firms as The General Electric Company, Timken-Detroit Axle Company, Dodge Motors, Pratt and Whitney Division, Monsanto Chemical Company, Greenfield Tap and Die Corporation.

How Are Deepfreeze Sub-Zero Temperatures Being Used?

The possibilities for applying Deepfreeze Industrial Chilling Machines in your plant are practically unlimited. Here are but a few of the many applications finding widespread use in industry today.

- Treating of high speed steel cutting tools.
- Shrinking of metal.
- Shrink-fit assembly.
- Stabilization of gages.
- Hardening of precision machine parts.
- Testing of aircraft instruments and materials.
- Testing of lubricants, paints, plastics, chemicals, synthetic rubber and pharmaceuticals.

How Can Sub-Zero Temperatures Be Adapted to My Work?

If, after checking Deepfreeze uses listed above, you are not sure how sub-zero temperatures can be beneficially applied to your manufacturing, let Deepfreeze engineers work with you in finding the solution to your industrial metal chilling problems. The Deepfreeze Industrial representative in your territory will be glad to assist you in handling sample parts for a Deepfreeze test in the factory laboratory. There is no obligation.

What About Delivery?

If you can qualify, under government priority regulations, you can expect prompt delivery on Deepfreeze standard chilling machines.

WHERE CAN I GET MORE INFORMATION?

The complete and latest data on the use of sub-zero temperatures for industrial use can be found in the new Deepfreeze Metal Chilling Data Book. A Deepfreeze representative will be glad to answer other questions you may have and can furnish you with any further information.

Deepfreeze

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rial Chilling Equipment for Shrinking, Testing, Hardening and Stabilizing Metals

Division of Motor Products Corporation, Detroit, Michigan

Metal Powders

(*Starts on page 886*)

Reduced and carbonyl iro show quite high flammability a low ignition temperatures, but t pressures and rates of pressure r are much below those of the mo hazardous powders. Antimon manganese, zinc, silicon and t are in the range expected for co dusts from high volatile to lo volatile bituminous. Silicon pr duced a high maximum pressu accompanied by low rates of pr sure rise. This element has a hi heat of combustion, but apparent has a low rate of reactivity towa oxygen in these tests.

The five metals at the bottom the table on page 887 (lead, ca mium, copper, iron and chromiu could not be ignited with the stan ard spark, and required a stro arc or a pellet of magnesium mix with barium peroxide. Resulti figures for pressure are omitte for they are not comparable wi those for the other tests, but e dently these powders present le hazard than those listed higher the table. The minimum ener required for spark ignition of d persions of a number of powders so small as to be insignificant practice. If the ignition tempe ture is reached there can hard fail to be sufficient energy f ignition.

Figures for two organic du of known hazard are appended the main table. Their rates pressure rise are considerab smaller than for the most haza ous metal powders, and theref venting can more effectively relie a pressure wave. The highest pr sure in the metal tests was me ured during an explosion test o magnesium powder, 72 psi., or ov 5 tons per sq.ft. The maxim rate of pressure rise in this t was nearly 5000 psi. per sec., a only 0.05 sec. elapsed between t ignition of the dust cloud and t instant when the maximum pr sure was reached. An explosion this intensity would result in co plete destruction of equipment a plant structure, despite careful designed relief vents.

Safety Codes — Production a use of certain powders should co ply with safety codes alrea developed by the National Fire Pr tection Association.

Great Britain Reviews Its Metallurgical Education

The Council of the Iron and Steel Institute, as a result of an inquiry from the British Government's Department of Scientific and Industrial Research, has given renewed attention to the "education which should be undertaken by those who wish to become metallurgists and to the training which is desirable for those who hope to gain their livelihood in the metallurgical industries".

The results of this survey are incorporated in a pamphlet "The Training of Metallurgists" published in February of this year. Copies can be secured from The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England, and it could be read with advantage by all in this country who are interested in metallurgical education.*

The report stresses the national importance of the subject. It states that the prosperity of Britain after the war will depend more than ever upon the efficiency and progressiveness of its industries. The supply, education and training of a sufficient number of metallurgists are among the most important steps which will make this possible.

Supply of Metallurgists — British industry will be faced, after the war, with a severe shortage of properly qualified metallurgists due partly to the comparatively small number of students who have taken courses in this specialized branch of the applied sciences, and partly to the greater proportion of trained men who will be needed. Before the war there were only 40 advanced, full-time students of metallurgy in universities or colleges in the United Kingdom. This number was but 4% of those studying chemistry.

Increased numbers will be required in the metallurgical industries for filling managerial positions and for research and development. This will be the inevitable result of the increased capacity in the industry and the increased need for control in all metallurgical operations.

Recruitment for Industry — Various means are suggested for attracting boys and young men to the metallurgical industries, including lectures to boys, and the preparation of attractive popular boys' books. More important is the maintenance of closer contacts with schools and the emphasis that should, in general education, be placed on the part the metallurgical industry plays in contributing to the prosperity *(Cont. on page 946)*

*This review was prepared by M. A. Hunter, head of the Department of Metallurgical Engineering of Rensselaer Polytechnic Institute, Troy, N. Y.

Metallurgical Education

(Continued from page 938) and well-being of th country. The report shows psychological wisdo when it states that the most effective means fo recruitment lies in the education of the parent

The present conditions of employment shoul also be scrutinized. Initial salaries should b adequate for the respective grades from whic recruitment takes place, and prospects for promo tion should be good for those with necessar qualifications.

Educational Policies — It has been announce that it is the British Government's policy to rais the minimum age for leaving school to 16 years and that part-time education in "Young People' Colleges" or similar institutions will be compul sory for all, up to the age of 18. One year of mili tary service will perhaps be compulsory betwee the ages of 18 and 19. Provision must therefor be made for an increased supply of teachers wit revision of salary scales in all grades to attrac teachers of ability.

It is recognized that vocational training fo those who leave school at the earliest permissibl age is undesirable. All recruits to industry at an educational level should have a proper knowledg of the English language and "a clear understand ing of the essential character and institutions o the society in which the students will be called t play their part".

Closer contacts should be maintained betwee industry and educational establishments. Indus try will secure lasting advantage by assisting i increasing to the highest level the qualifications o those in the teaching profession, and in providin technical equipment for the laboratories.

The Universities — The object of a universit education must be to provide a wide knowledge o the basic sciences rather than to turn out special ists who can, on entering industry, fill responsibl positions and earn large salaries. The presen tendency towards specialization should be checked But students at universities should spend part o their long vacations in works or suitable labora tories.

The first period of the student's educatio should be in basic scientific subjects, includin mathematics and the principles of engineerin with special emphasis on chemistry and physics The second period should be devoted to a continua tion of scientific studies and particular study o process and physical metallurgy. In the case o selected men, graduation in physics or chemistr may be suitably followed by two years post-grad uate study in metallurgy. (Continued on p. 950)

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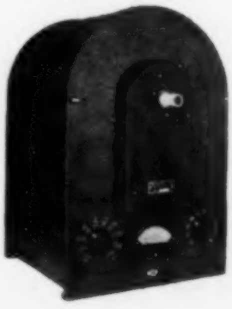
ANALYSIS OF ALL METALS

MINUTE SULFUR DETERMINATOR

improved Sulfur Determinator provides rapid and accu- sulfur determination of coal, coke, irons, alloy steels, and ferrous or non-ferrous materials. The time required for plete analysis, exclusive of weighing sample, is 3 minutes. e determinator has a substantial base and supporting n for holding glassware. Three 2-liter solution es insure ample supply of chemicals for the two matic pipettes and burette.

simplified titration vessel facilitates cleaning, inates breakage of expensive glassware, and les the operator to leave a sample burning the other is being titrated. The bubbler is also vable so that it may also be easily cleaned. e Varitemp Furnace, illustrated at right, has a erature range up to 2750° Fahr. and is fur- d complete with transformer, pyrometer, volt- control, and power switch. This unit may be with either the Carbon or Sulfur Determinator.



2-MINUTE CARBON DETERMINATOR

The improved 2-minute Carbon Determinator enables operators to determine carbon content of all metals with speed and accuracy. It incorporates new features which eliminate much of the human equation and simplifies procedure. A complete determination can be made within 2 minutes after the sample is weighed.

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The absorption vessel is of a "U" tube design and provides a positive means of having the gas pressure in the Determinator at atmospheric pressure at the end of the combustion period and at the time the reading is taken. At the atmospheric liquid level is located a capillary tube with a line marker. This eliminates the doubtful eye leveling procedure and inaccuracies due to difference in pressure at the start and finish of test.

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Metallurgical Education

(Continued from page 946)

Education Below University Standard—M of the recruits to industry will continue to co direct from secondary schools. From this categ a large proportion of the managers in metallurg industries is now drawn. The technical and sc tific education of these lads must be underta *after* they have entered industry.

It is therefore proposed that compuls attendance at Young People's Colleges or equi lent institutions shall begin with one day a we to be later extended to half the normal we This is expected to supplement (and later sup sede) the present voluntary attendance at even classes. Many of the technical colleges now p vide evening class facilities of university sta ards, for the study of metallurgy.

The part which industry must play in enco aging part-time education is of paramount imp tance. Here Works Schools and apprent training now play a large part, but central te nical colleges can provide training in engineer and the sciences on a wider basis.

Suggestions are given in the report for ad education for managers and other staff offic and for foremen and workmen. While such m have exceptional knowledge of processes and ma rials and fine manipulative skill, they can pr by acquiring knowledge of the principles of scie and engineering and the theory behind the pr esses which they now employ.

The improved facilities for education and greater encouragement to enter the metallurg industries which have been suggested should re in more boys and men of first class ability stu ing metallurgy. However, preference will conti to be given by students, parents and teachers chemistry and the various branches of engineer as long as those who reach a given standard these subjects are able to obtain nationally rec nized qualifications, such as membership in Royal Institute of Chemistry and in the Insti tions of Civil and Mechanical Engineers. Brit metallurgists, to their disadvantage, have no si lar prospects of national recognition.

This report, even though it applies primar to conditions in England, should be of interest many Americans, both educators in the field metallurgy or of metallurgical engineering, a industrialists who are to use the products of t education. If the suggestions made are diligen followed up, British metallurgy will be in a bet position to meet the competition in science and industry which all of us foresee.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

METAL WORKING • FABRICATION

Marvel metal cutting saws. Armstrong-Blum Mfg. Co. Bulletin 395.

Powdered metal presses. Kux Machine Co. Bulletin 1.

Forging presses. Ajax Mfg. Co. Bulletin 2.

Horizontal extrusion presses. Hydropress, Inc. Bulletin 3.

36-page pictorial story of the Cecostamp. Chambersburg Engineering Co. Bulletin 4.

Cutting Oils. Cities Service Oil Co. Bulletin 5.

Presses for Powder Metallurgy. F. J. Stokes Machine Co. Bulletin 7.

Information and data on straightening press. Anderson Bros. Mfg. Co. Bulletin 10.

Properties and uses of cutting oils. Gulf Oil Corp. Bulletin 8.

Surface coated abrasive belts. Minnesota Mining & Mfg. Co. Bulletin 12.

Presses for the metal working and process industries. Hydraulic Press Mfg. Co. Bulletin 20.

Savings in oils, tool bits, grinding wheels. Sparkler Mfg. Co. Bulletin 15.

New catalog illustrates standard, non-standard, and special tools. Kennametal, Inc. Bulletin 250.

Mounted wheels, Handee and Hi-Power tools. Chicago Wheel & Mfg. Co. Bulletin 21.

20-page booklet on cutting fluids. Tide Water Associated Oil Co. Bulletin 252.

Air tools in steel mills and foundries are pictured in new booklet by Ingersoll-Rand. Bulletin 255.

Big, comprehensive catalog illustrates line of power presses offered by Minster Machine Co. Bulletin 320.

Complete and valuable study of "Machining of Metals", including chip formation, is offered by National Refining Co. Bulletin 335.

Safe-T tongs and their use in materials handling are described in new booklet by Heppenstall Co. Bulletin 434.

63-page pocket booklet shows useful tables of weights and measures used in the metal industry. Mesta Machine Co. Bulletin 441.

Practical data sheet describes cutting and grinding compound. Diversey Corp. Bulletin 447.

8-page general catalog outlines th hard facing alloys and overlay met als of this company, with many illustrations and typical applications Wall-Colmonoy Corp. Bulletin 48

This company has issued two new booklets showing new price lists fo sintered carbides. Firth-Sterling Steel Co. Bulletin 486.

"Quality Control" is the title o this new 64-page pocket size hand book on scientific inspection. Continental Machines, Inc. Bulletin 479

20-page booklet discusses typical problems involved in the selection and application of water-mix oils. D A. Stuart Oil Co., Ltd. Bulletin 482

FERROUS METALS

Republic Steel Corp.'s second edition of National Emergency Steels tells you all about these new steels Bulletin 345.

Aircraft steels, bearing steels. Rotary Electric Steel Co. Bulletin 24

Page after page of useful technical data and reference tables on tool steels. Latrobe Electric Steel Co. Bulletin 367.

Steel Data Sheets. Wheelock, Lovejoy & Co. Bulletin 25.

Use Handy Coupon Below for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 970, 972, 974, 975, 976 980, 984, 986, 988, 992, 994, 996 and 998.

Metal Progress 7301 Euclid Ave., Cleveland 3, Ohio May, 194

Send me the Literature I have indicated below.

Name .... **Title** ....

Company .... **Address** ....

(Students—please write direct to manufacturers).

Check or circle the numbers referring to literature described on these 14 pages.

1	41	79	107	146	174	202	271	323	357	385	433	457	478
2	42	82	109	147	175	203	281	324	359	388	434	458	479
3	43	83	114	148	176	204	284	325	360	390	435	459	480
4	45	84	115	149	177	206	288	327	361	395	436	461	481
5	48	85	116	150	179	207	291	328	362	397	437	462	482
7	51	86	117	152	180	208	292	329	363	398	438	463	483
8	56	89	118	154	182	210	296	330	364	399	439	464	484
10	57	91	119	155	183	212	297	331	365	404	440	465	485
12	59	93	122	156	184	213	301	333	366	406	441	466	486
15	60	94	123	158	185	215	305	335	367	407	445	467	487
20	62	95	128	161	186	232	307	337	368	409	446	468	488
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24	66	97	134	163	190	240	313	339	372	411	448	470	490
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26	70	99	137	165	193	243	315	345	375	420	450	472	
30	71	101	139	167	196	246	316	347	376	421	452	473	
31	72	102	141	170	197	250	318	350	377	422	453	474	
33	75	103	142	171	199	252	319	351	380	424	454	475	
35	76	105	143	172	200	255	320	353	383	426	455	476	
40	78	106	144	173	201	258	322	354	384	428	456	477	

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Molybdenum wrought steels. Molybdenum Corp. of America. Bulletin 26.

Free Machining Steels. Monarch Steel Co. Bulletin 30.

Chemical analyses, shapes and sizes of Joslyn stainless steel products. Joslyn Mfg. and Supply Co. Bulletin 297.

Tool Steels. Bethlehem Steel Co. Bulletin 31.

Enameling iron sheets. Inland Steel Co. Bulletin 33.

Loose-leaf reference book on molybdenum steels. Climax Molybdenum Co. Bulletin 35.

Aircraft Alloy Steels. Joseph T. Ryerson & Son, Inc. Bulletin 40.

Kinite alloy tool steel bar stock. H. Boker & Co., Inc. Bulletin 258.

New Catalog C makes it easy to get International Nickel Co. literature, as it presents brief description and index to a wide variety of booklets. Bulletin 305.

"Graphitic Booklet" gives complete information on new, free-machining, long-wearing steel. Steel & Tube Div., Timken Roller Bearing Co. Bulletin 307.

Spark Testing Guide—a 21" x 30" wall chart—is useful in segregating tool steel scrap, unscrambling mixed stocks and checking identity of tool steel before heat treatment. Carpenter Steel Co. Bulletin 312.

HWD hot work die steel and Sterling stainless steels are described in four new leaflets by Firth-Sterling Steel Co. Bulletin 323.

Engineering and comparative information on porcelain enameled iron is presented in new illustrated booklet by American Rolling Mill Co. Bulletin 376.

New booklet gives full information on N-A-X high tensile and N-A-X 9100 Series of alloy steels. Great Lakes Steel Corp. Bulletin 328.

Attractive new catalog describes the line of steel offered by Peninsular Steel Co. Bulletin 337.

Technical data booklet on Mo-Max steels is offered by Cleveland Twist Drill Co. Bulletin 435.

Spindle speed calculator is handy chart to figure machining rates on bar steels. Bliss & Laughlin, Inc. Bulletin 333.

64-page booklet describes the welding of stainless steels. Allegheny Ludlum Steel Corp. Bulletin 384.

84-page tool and die steel handbook just issued by Ziv Steel & Wire Co. is a helpful guide to selection, treatment and use of these important steels. Bulletin 440.

32-page booklet which pictorially and textually amounts to a scientific treatise on two carbon steels—Speed Case and Speed Treat—has been issued by W. J. Holliday & Co. Bulletin 450.

Fitzsimons Co. issues interesting leaflet on speed case and speed treat steels. Bulletin 452.

NON-FERROUS METALS

This "Aluminum Imagineering Notebook" presents 12 important economic advantages of aluminum and illustrates numerous examples of things which have been imagineered into aluminum actualities. Aluminum Co. of America. Bulletin 472.

80-page pipe and tube bending handbook has been issued by Copper & Brass Research Assn. Bulletin 399.

Platinum Metal Catalysts. Baker & Co., Inc. Bulletin 41.

Die casting equipment. Lester-Phoenix, Inc. Bulletin 42.

Copper Alloys. American Brass Co. Bulletin 45.

Handy & Harman has issued a revised edition of their general catalog on Sil-Fos and Easy-Flo brazing alloys. Bulletin 43.

Brass and bronze castings. Hammond Brass Works. Bulletin 48.

6th edition of Revere Weights and Data Handbook. Revere Copper and Brass, Inc. Bulletin 296.

Rare metals, alloys and ores. Foote Mineral Co. Bulletin 56.

Brazing Booklet. Westinghouse Elec. & Mfg. Co. Bulletin 57.

Dowmetal data book. Dow Chemical Co. Bulletin 51.

Two new Ampco Metal data sheets discuss forging Ampco to improve physical characteristics and use of Ampco for non-scratching feed fingers. Bulletin 314.

20-page book shows each step in production of brass and aluminum castings by Manufacturers Brass Foundry Co. Bulletin 414.

"Designing with Magnesium" is title of new book offered by American Magnesium Corp. Bulletin 433.

WELDING

40-page catalog reviews the progress and many applications of low temperature welding. Eutectic Welding Alloys Co. Bulletin 471.

Use Handy Coupon on Page 968 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 968, 972, 974, 975, 976, 980, 984, 986, 988, 992, 994, 996 and 998.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

16-page booklet outlines the many advantages of the P. & H. control system for production welding. Harnischfeger Corp. Bulletin 474.

Welding Stainless. Page Steel & Wire Div., American Chain & Cable Co., Inc. Bulletin 59.

Oxy-acetylene welding and cutting. Linde Air Products Co. Bulletin 62.

Chart explains how to select proper flux for every welding, brazing and soldering job. Krembs & Co. Bulletin 60.

Welding and brazing of aluminum, a new data book issued by Aluminum Co. of America. Bulletin 66.

Data book facts on spot, seam and flash welding ferrous and non-ferrous metals and alloys. P. R. Mallory & Co., Inc. Bulletin 65.

Shield Arc electrodes. McKay Co. Bulletin 67.

New 12-page booklet tells how to fabricate fittings for welded piping by means of flame-cutting and welding. Air Reduction Co. Bulletin 234.

Atomic-hydrogen arc welding, its application and use, is described by General Electric Co. in new Bulletin 241.

New 500 lb. capacity welding positioner for light welding jobs is described by Ransome Machinery Co. Bulletin 313.

Nu-Braze No. 4, an improved silver brazing alloy. Sherman & Co. Bulletin 288.

Two new hard-facing alloys furnished as welding rods for application by Oxy-Acetylene process are described by the Stoody Co. in Bulletin 325.

New line of welding positioners with dual capacity are described in new booklet by Harnischfeger Corp. Bulletin 350.

Vest pocket guide to correct welding practices is offered by Hobart Brothers Co. Bulletin 351.

Comparable arc welding electrodes for stainless are shown in chart issued by Alloy Rods Co. Bulletin 353.

Helpful electrode color chart is offered by the Arcos Corp. Bulletin 374.

Arc welding inspection chart, designed so that operators can tell at a glance whether welds are being properly made, has been issued by the Lincoln Electric Co. Bulletin 411.

Use Handy Coupon on Page 968 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 968, 970, 974, 975, 976, 980, 984, 986, 988, 992, 994, 996 and 998.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

New Phos-Copper booklet explains ways to braze, design and applications. Westinghouse. Bulletin 455.

16-page booklet describes the welding and cutting equipment. Victory Equipment Co. Bulletin 489.

TESTING & INSPECTION

Latest technical literature on x-ray and radium protection, together with lead products catalog, has been issued by Bar-Ray Products, Inc. Bulletin 463.

Magnetic analysis equipment for inspecting steel bars and steel tubes is described in this booklet by Magnetic Analysis Corp. Bulletin 464.

The Bristol-Rockwell dilatometer and its use is described in this leaflet by The Bristol Co. Bulletin 465.

250 KV industrial x-ray units—jib crane, mobile and dolly—are described in this new booklet. Picker X-Ray Corp. Bulletin 468.

Metallurgical polishing equipment offered by Precision Scientific Corp. is described in illustrated booklet. Bulletin 359.

Various methods and specific applications of the measurement of case depth are described in illustrated pamphlet offered by Allen B. DuMont Laboratories, Inc. Bulletin 339.

Bibliography of more than 70 papers dealing with the polarographic method of metal analysis and a booklet discussing this equipment is offered by E. H. Sargent & Co. Bulletin 338.

SR-4 strain gage and illustrations of its many uses. Baldwin Southwark. Bulletin 70.

New book contains wealth of practical, usable information on industrial inspection by x-ray. Westinghouse Electric & Mfg. Co. Bulletin 71.

X-Ray Diffraction Unit. General Electric X-ray Corp. Bulletin 72.

Electric heaters and controls for industrial and laboratory. American Instrument Co. Bulletin 75.

Inspection of non-magnetic metals with the new Zyglo method. Magnaflux Corp. Bulletin 78.

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Industrial radiography with radium. Canadian Radium & Uranium Corp. Bulletin 79.

Gage blocks, comparators, projectors. George Scherr Co. Bulletin 83.

Portable Brinell hardness tester and folding Brinell microscope. Andrew King. Bulletin 85.

Universal testing machines and typical uses. Riehle Testing Machine Div., American Machine and Metals, Inc. Bulletin 86.

Dillon tensile tester and the Dillon dynamometer. W. C. Dillon & Co. Bulletin 91.

Optical Aids. Bausch & Lomb Optical Co. Bulletin 94.

Coleman universal spectrophotometer. Wilkens-Anderson Co. Bulletin 95.

Metallographic polishing powder. Conrad Wolff. Bulletin 96.

Metallurgical Equipment. Adolph I. Buehler. Bulletin 97.

"Radiography of Materials" is title of new 96-page book on industrial radiography. Eastman Kodak Co. Bulletin 331.

Stresscoat, a method of analyzing distribution, direction and value of local strains. Magnaflux Corp. Bulletin 301.

Hardness testing equipment. Wilson Mechanical Instrument Co., Inc. Bulletin 98.

Attractive, illustrated booklet describes Clark Instrument's precision hardness tester. Bulletin 318.

Two new folders describe Searchray 80, new self-contained X-ray unit of North American Philips Co. Bulletin 377.

High intensity industrial illuminator is illustrated and described in new leaflet by Kelley-Koett Mfg. Co. Bulletin 406.

30th Anniversary Catalog shows the special metallurgical equipment offered by Claud S. Gordon Co. Bulletin 410.

Laboratory and industrial pH meters are described and explained in leaflet issued by Beckman Instruments Division. Bulletin 422.

8-page illustrated leaflet describes line of industrial instruments offered by the Brush Development Co. Bulletin 428.

Use Handy Coupon on Page 968 for Ordering Helpful Literature.
Other Manufacturers' Literature Listed on Pages 968, 970, 972, 974, 976, 980, 984, 986, 988, 992, 994, 996 and 998.

WHAT'S NEW

IN MANUFACTURERS' LITERATU

TEMPERATURE CONTROL

New 29-page catalog — Microma Electric Control — has just been is sued by Leeds & Northrup Co. Bu letin 76.

Potentiometer temperature indica tors. Foxboro Co. Bulletin 82.

Micro-Optical Pyrometers. Pyrom eter Instrument Co. Bulletin 89.

Pyrometer control of high spee salt baths is described in new book let by Brown Instrument Co. Bulle tin 324.

Pyrometer Controller. Illinois Test ing Laboratories, Inc. Bulletin 84.

Industrial thermocouples. Arkla S. Richards Co. Bulletin 93.

New Pyrometer Accessory Man ual gives engineering data on selec tion and installation of thermo couples. The Bristol Co. Bulletin 421.

Operating principle and type available of the synchronous-motor driven cam program timer are cov ered in this new 4-page folder Automatic Temperature Control Co. Inc. Bulletin 487.

36-page thermocouple data book and catalog describes products prices and presents recommenda tions for thermocouple users. Wheel co Instruments Co. Bulletin 490.

HEATING • HEAT TREATMENT

"Isothermal Quench Baths Applied to Commercial Practice" is the title of this 12-page paper, a practica and useful discussion of S curves i heat treatment. Ajax Electric Co. Inc. Bulletin 461.

32-page booklet describes 16 inter esting industrial uses of high fre quency electrical induction. Ohi Crankshaft Co. Bulletin 459.

Quenching oil coolers in heat treat ing practices are described in this leaflet by the Sims Co. Bulletin 462

New catalog No. 406 describes Rockwell valves for control of air gas and liquids. W. S. Rockwell Co. Bulletin 466.

Neutral baths for heat treatment and details of their use are described in this booklet by the A. F. Holden Co. Bulletin 469.

Use Handy Coupon on Page 968 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 968, 970, 972, 974, 975, 980, 984, 986, 988, 992, 994, 996 and 998.

WHAT'S NEW

IN MANUFACTURERS' LITERATU

24-page technical data and oper-ing manual covering the Deepfre low temperature industrial chilli machines has been issued by De freeze Div., Motor Products Co Bulletin 398.

36-page catalog illustrates Kol Hold line of thermal, sub-zero a stratosphere processing and testi machines. Kold-Hold Mfg. Co. Bul tin 99.

Induction heating. Induction He ing Corp. Bulletin 103.

Internally heated salt bath furnac and pots. Upton Electric Furna Div. Bulletin 102.

Easy-selection charts on g burning equipment. National M chine Works. Bulletin 105.

8-page pictorial bulletin descri the heat treating service of Con nental Industrial Engineers, Inc. Bu letin 107.

Electric Furnaces. Ajax Electi thermic Corp. Bulletin 106.

Lithco, the chemically-neutral he treating process, and Lithcarb, th process for fast, bright gas-carburi ing. Lithium Corp. Bulletin 101.

Furnaces for heat treatment of alu minum, magnesium and their alloy Lindberg Engineering Co. Bullet 271.

Gas, oil, and electric heat treatin and carburizing furnaces. Holcro & Co. Bulletin 114.

Industrial furnaces, equipment fo bright annealing stainless steels an ammonia dissociation equipmen Drever Co. Bulletin 115.

Industrial ovens, rod bakers, weld ing rod ovens, furnaces. Carl-May Corp. Bulletin 116.

Full muffle and other heat treatin furnaces described in catalog b Charles A. Hones, Inc. Bulletin 11

Non-metallic Electric Heating El ments. Globar Div., Carborundu Co. Bulletin 119.

56-page vest pocket data book c heat treating practices and proc dures. Chicago Flexible Shaft C Bulletin 118.

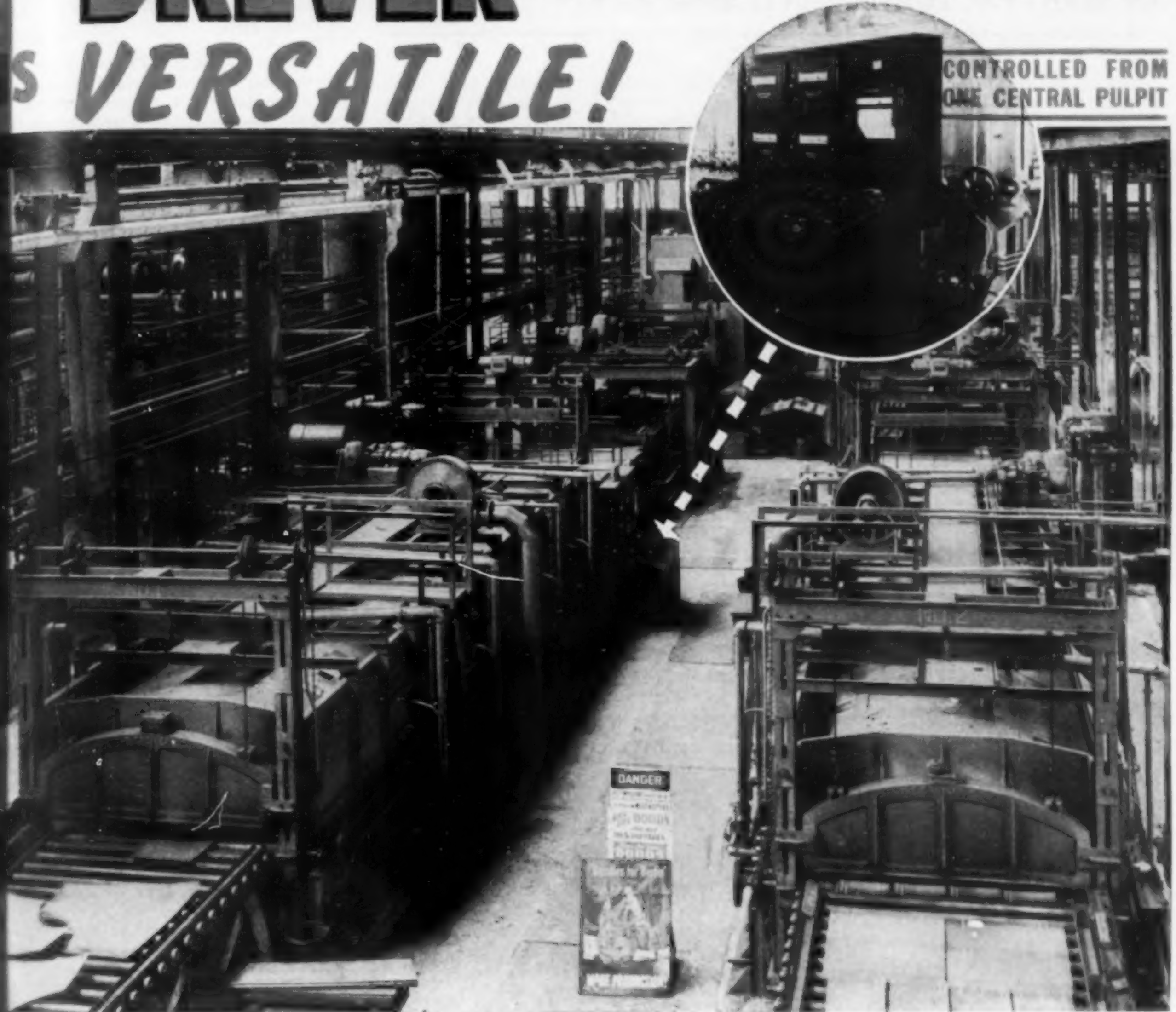
Control of temperatures of quenc ing baths. Niagara Blower Co. Bu letin 122.

Molten Salt Baths. E. I. duPon deNemours & Co., Inc., Electrochem icals Department. Bulletin 123.

Use Handy Coupon on Page 968
for Ordering Helpful Literature.
Other Manufacturers' Literature
Listed on Pages 968, 970, 972, 974, 97
976, 984, 986, 988, 992, 994, 996 and 998.

THE DREVER ROLLER HEARTH LINE IS VERSATILE!

CONTROLLED FROM ONE CENTRAL PULPIT



Although the Drever Roller Hearth furnace line with Drever Automatic Quench was developed primarily as a low-cost, high production armor plate heat treating unit, the experience of users proves that there is no such strict limitation on its use.

Already, users report outstanding success in the treatment of a variety of sheets and plates, bar stock, pins and miscellaneous parts, not related to the original production of the installations.

The versatility of the Drever Roller Hearth line merits your consideration. We will be pleased to discuss specific details at your convenience.

EXPERIENCE POINTS TO THE DREVER CO

THE DREVER CO.

790 E. VENANGO ST., PHILADELPHIA 34, PA.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Handling cylinder anhydrous ammonia for metal treaters. Armour Ammonia Works. Bulletin 128.

Certain Curtain Furnaces. C. I. Hayes, Inc. Bulletin 134.

Air-Oil Ratiotrol for proportioning flow of fuel oil and air to oil burners. North American Mfg. Co. Bulletin 135.

Two new bulletins on vertical carburizers and on carbonia finish. American Gas Furnace Co. Bulletin 139.

Van Norman induction heating units. Van Norman Machine Tool Co. Bulletin 144.

Controlled atmosphere furnace. Delaware Tool Steel Corp. Bulletin 141.

Dual-Action quenching oil. Gulf Oil Co. Bulletin 132.

Furnaces. Tate-Jones Co. Bulletin 142.

Industrial Carburetors. C. M. Kemp Mfg. Co. Bulletin 143.

Heat treating, brazing and melting of ferrous and non-ferrous metals. Lepel High Frequency Laboratories, Inc. Bulletin 147.

Vertical Furnace. Sentry Co. Bulletin 148.

Conveyor Furnaces. Electric Furnace Co. Bulletin 149.

High and low temperature direct fired furnaces. R-S Products Corp. Bulletin 146.

New Electric Furnace. American Electric Furnace Co. Bulletin 150.

Electric Furnaces for laboratory and production heat treatment. Hoskins Mfg. Co. Bulletin 152.

"The Lectrodryer in the metallurgical industries," a new 4-page bulletin by Pittsburgh Lectrodryer Corp. Bulletin 155.

Pictorial bulletin describes furnaces for heat treating, normalizing, annealing, forging. Vulcan Corp. Bulletin 161.

High Temperature Fans. Michiana Products Corp. Bulletin 158.

Protective combusted atmospher[e] in Hevi Duty Electric Co. furnac[es] are discussed in 12-page Bulletin 31[?]

Flame-type mouth and taper a[n]nealing machine for steel cartrid[ge] cases. Morrison Engineering Cor[p.] Bulletin 154.

Turbo-Compressor data boo[k] shows how to calculate compresse[d] air systems for a dozen different a[p]plications. Spencer Turbine Co. Bu[l]letin 329.

No-Carb, a liquid paint for preve[n]tion of carburization or decarburiz[a]tion. Park Chemical Co. Bulleti[n] 156.

Catalog of heat treating material[s.] Heatbath Corp. Bulletin 322.

Standardized sizes of semi-muff[le] and pot-type furnaces are describe[d] and pictured in new leaflet by Demp[]sey Industrial Furnace Corp. Bu[l]letin 354.

Use of pulverized coal in the meta[l]lurgical industries, equipment an[d] designs, are described by Amsler Morton Co. in Bulletin 361.

Illustrated bulletin on stress-relie[v]ing, car-type furnaces. Radian[t] Combustion. Bulletin 375.

Furnaces for heat treating tool[s,] dies and parts are described in ne[w] leaflet by Despatch Oven Co. Bu[l]letin 362.

Rapid oil coolers and heat transf[er] equipment are described in new cat[a]log issued by Bell & Gossett C[o.] Bulletin 365.

New book "Hardness" describ[es] and evaluates hardness research [of] noted pioneers, methods of testi[ng] and testing instruments. Nitrallo[y] Corp. Bulletin 366.

New booklet describes unifor[m] case hardening up to .150" with co[n]trolled carburizing baths. America[n] Cyanamid & Chemical Corp. Bu[l]letin 372.

82-page catalog describes in det[ail] General Electric heat treat furnace[s.] Bulletin 380.

Four basic heat treating atmo[s]pheres are described in new bookl[et] by Westinghouse. Bulletin 383.

Laboratory and tool room furnac[es.] Mahr Mfg. Co. in new Bulletin 327.

"Heat Treating Topics" is title [of] new bulletin of special interest [to] heat treaters, issued by Rex & Er[] Bulletin 424.

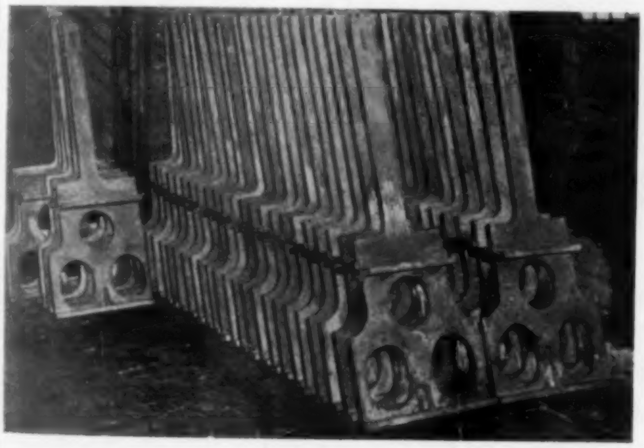
Vapocarb-Hump method for he[at] treatment of steel is the title of [a] newly-revised catalog issued b[y] Leeds & Northrup. Bulletin 453.

Use Handy Coupon on Page 968 for Ordering Helpful Literature.
Other Manufacturers' Literature Listed on Pages 968, 970, 972, 974, 97[] 976, 980, 986, 988, 992, 994, 996 and 998.

HIGH ALLOY CASTINGS

DURALOY

Take the Punishment of HIGH TEMPERATURES and CORROSIVE CONDITIONS



Service from an incorrectly alloyed and poorly made high alloy casting may be as unsatisfactory as from a casting of ordinary steel or grey iron.

Duraloy Castings are produced by specialists in chrome-iron and chrome-nickel, often with other alloying elements. They give a quality service under severe high temperatures and biting corrosive conditions.

Starting in 1922, Duraloy was one of the first to commercially produce chrome-iron and chrome-nickel castings. And in 1931 was among the first to produce *centrifugal castings.*

With a modern and complete foundry, including several electric furnaces, sand-testing equipment, annealing furnace and machine shop, Duraloy can produce rough or finished castings ranging from a pound up to several tons.

Consult us on your casting requirement. We will be glad to help on the selection of alloying elements, if desired.

THE DURALOY COMPANY

OFFICE AND PLANT: SCOTTDALE, PA.

Eastern Office: 12 East 41st St., New York 17, N. Y.

Los Angeles: Kilsby & Graham

Chicago & Detroit: F. B. Cornell & Associates

Scranton, Pa.: Coffin & Smith

Metal Goods Corp.: St. Louis - Houston - Dallas - Tulsa - New Orleans - Kansas City

5-DU-2

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

The complete line of heat treating furnaces, burners and other equipment of this company is described and illustrated in new bulletin "D" just issued. Eclipse Fuel Engineering Co. Bulletin 483.

Thirty-two-page booklet, "Production Data," presents several articles from "The Houghton Line." E. F. Houghton & Co. Bulletin 475.

Industrial forge furnaces are described and illustrated in this 4-page folder. Surface Combustion. Bulletin 476.

112 pages packed solid with down-to-earth data on industrial combustion and heat practice. Hauck Mfg. Co. Bulletin 477.

A new technical bulletin gives information on Calliflex Bi-metal. Callite Tungsten Corp. Bulletin 478.

REFRACTORIES & INSULATION

Insulating firebrick. Babcock & Wilcox Co. Bulletin 162.

Heavy Duty Refractories. Norton Co. Bulletin 164.

Cromox, new protective refractory coating material for prolonging life of firebrick, insulating firebrick, and castable refractories. Federal Refractories Corp. Bulletin 163.

Super Refractories catalog. Carborundum Co. Bulletin 165.

Conductivity and heat transfer charts. Johns-Manville. Bulletin 167.

D-E insulating materials and their application are described in new data booklet by Armstrong Cork Co. Bulletin 208.

Zircon refractories in aluminum open hearth furnaces. Chas. Taylor Sons Co. Bulletin 347.

"Gunmix", a new series of refractories designed for rapid emplacement by air stream and water, is described and illustrated. Basic Refractories, Inc. Bulletin 480.

Use Handy Coupon on Page 968 for Ordering Helpful Literature.
Other Manufacturers' Literature Listed on Pages 968, 970, 972, 974, 975, 976, 980, 984, 988, 992, 994, 996 and 998.

LABELS WORTH REMEMBERING

The Fastest, Most Positive Metal Cleaners that Experience Can Produce!

We know this sounds like boasting, but we are exceptionally proud of these three trade-marks . . . proud of the work that METEX, METALEX and ANODEX compounds are doing in speeding-up and improving war production . . . proud of the work we have done to make these names the leaders they are today.

Old-timers will remember METEX as the MAC DERMID INCORPORATED trade-mark for one of the first cleaners developed for specific applications and METALEX compounds as among the first "made to measure" cleaners perfected for simplified cleaning operations. ANODEX reverse current process and compounds made history at the introduction of reverse current cleaning and like the others, is still the established leader in its field.

Today there are over fifty individual formulations perfected for faster, more positive cleaning of all metals and alloys and with every type of equipment . . . No wonder we are proud!

Compounds for Cleaning Made to the Measure of Modern Production

MAC DERMID

INCORPORATED

WATERBURY 88, CONNECTICUT

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Udylite Corp. (L. I. City)	Udylite Corp. Wagner Bros.	Udylite Corp. Geo. A. Stutz Mfg. Co.	Udylite Corp. McGean Chem. Co.	LaSalco, Incorporated	Clark Industrial Supplies Co.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Steel Plant Cement for hot or cold patching of soaking pits, open hearths, electric furnaces, forging furnaces and reheating furnaces is described in new folder by Electro Refractories & Alloys Corp. Bulletin 407.

FINISHING • PLATING • CLEANING

Two new data sheets describe pickle bath toners in liquid and powder form. American Chemical Paint Co. Bulletin 467.

Automatic and semi-automatic plating equipment for a variety of processes and products are illustrated in 40-page booklet issued by Frederic B. Stevens, Inc. Bulletin 397.

Roto-Finish equipment for deburring, buffing, polishing and coloring. Sturgis Products Co. Bulletin 170.

A protective, deep black finish to steel. Heatbath Corp. Bulletin 171.

Alvey Ferguson Co. shows how various product washing problems were solved. Bulletin 172.

Motor-Generators for electroplating and other electrolytic processes. Columbia Electric Mfg. Co. Bulletin 173.

Pickling. Wm. M. Parkin Co. Bulletin 174.

Detrex metal cleaning machines, metal cleaning chemicals and processing equipment. Detrex Corporation. Bulletin 175.

Electrochemical Descaling. Bullard-Dunn Process Div., Bullard Co. Bulletin 212.

Airless Rotoblast. Pangborn Corp. Bulletin 176.

Cadmium Plating. E. I. duPont deNemours & Co., Inc. Bulletin 177.

Rust inhibiting wax coatings for protection of metal. S. C. Johnson & Son, Inc. Bulletin 180.

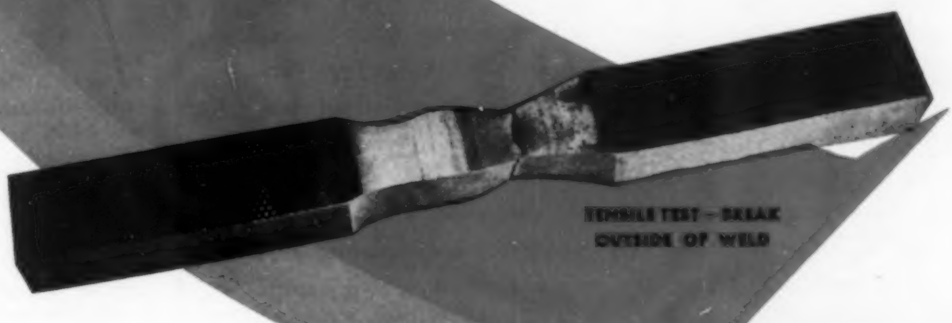
Use Handy Coupon on Page 968 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 968, 970, 972, 974, 975, 976, 980, 984, 986, 992, 994, 996 and 998.

WELDING STAINLESS CLAD

Arcos has a bulletin describing this Stainless Clad job . . . the grade of electrodes used, the technique of welding, and the welding procedure involved. This bulletin will be mailed you upon request or ask your Arcos Distributor for it.

Samples illustrated are 1¼" plate of which ¼" is 13% Chromium Steel.



ARCOS CORPORATION
401 NORTH BROAD ST., PHILADELPHIA 3, PA.

it's ARCOS for stainless electrodes

"QUALITY WELD METAL EASILY DEPOSITED"

Distributors Warehouse Stocks in the Following Cities:

Baton Rouge, La.	Wm. D. Seymour Co.
Borger, Texas	Hart Industrial Supply Co.
Boston, Mass.	H. Boker & Co., Inc.
Buffalo, N. Y.	Root, Neal & Co.
Chicago, Ill.	Machinery & Welder Corp.
Cincinnati, Ohio	Williams & Co., Inc.
Cleveland, Ohio	Williams & Co., Inc.
Columbus, Ohio	Williams & Co., Inc.
Detroit, Michigan	C. E. Philips & Co., Inc.
Erie, Penna.	Boyd Welding Co.
Fresno, Calif.	Victor Equipment Co.
Ft. Wayne, Ind.	Wayne Welding Sup. Co., Inc.
Honolulu, Hawaii	Hawaiian Gas Products, Ltd.
Houston, Texas	Champion Rivet Co. of Texas
Kansas City, Mo.	Welders Supply & Repair Co.
Kingsport, Tenn.	Slip-Not Belting Corp.
Los Angeles, Calif.	Victor Equipment Co.
Milwaukee, Wis.	Machinery & Welder Corp.
Moline, Ill.	Machinery & Welder Corp.
Montreal, Canada	G.D. Peters & Co. of Canada, Ltd.
New Orleans, La.	Wm. D. Seymour Co.
New York, N. Y.	H. Boker & Co., Inc.
Oklahoma City, Okla.	Hart Industrial Supply Co.
Pampa, Texas	Hart Industrial Supply Co.
Pittsburgh, Pa.	Williams & Co., Inc.
Portland, Ore.	J. E. Haseltine & Co.
Rochester, N. Y.	Welding Supply Co.
San Diego, Calif.	Victor Equipment Co.
San Francisco, Calif.	Victor Equipment Co.
Seattle, Wash.	J. E. Haseltine & Co.
St. Louis, Mo.	Machinery & Welder Corp.
Syracuse, N. Y.	Welding Supply Co.
Wichita, Kansas	Watkins, Inc.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Tumbling and cleaning. Globe Stamping and Machine Co. Bulletin 179.

Catalog on finishing and cleaning. Frederick Gumm Chemical Co., Inc. Bulletin 292.

Resilon corrosion-resistant tank linings and applications are described in 8-page leaflet by United States Stoneware Co. Bulletin 291.

"Indium and Indium Plating". Indium Corp. of America. Bulletin 18[illegible]

Jetal process and its characteristics as a protective coating. Alrose Chemical Co. Bulletin 213.

Illustrated booklet describes blast cleaning equipment offered by Ruemelin Mfg. Co. Bulletin 360.

Lead plating is discussed in new booklet issued by Harshaw Chemical Co. Bulletin 109.

Discussion of anodizing, chromatizing and phosphatizing in illustrated 60-page book has been issued by Turco Products, Inc. Bulletin 243.

Service report describes use of Oakite machining, drawing, degreasing and descaling materials. Oakite Products, Inc. Bulletin 210.

Three new booklets have been issued by the Enthone Co. describing an acid addition agent, hard drying rust-inhibiting waxes and a new alkali steel cleaner. Bulletin 420.

Special data sheets on compounds for various cleaning jobs are offered by MacDermid, Inc. Bulletin 436.

Technical bulletin describes materials developed to meet specialized processing and cleaning needs. Kelite Products, Inc. Bulletin 438.

New 1944 catalog describes metal cleaning equipment offered by N. Ransohoff, Inc. Bulletin 439.

Several practical data sheets show cleaning methods used on aluminum, brass and steel. Diversey Corp. Bulletin 446.

Use Handy Coupon on Page 968
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Other Manufacturers' Literature
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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

New 144-page catalog "Chemicals by Glyco" features many tables of useful chemical and physical data. Glyco Products Co., Inc. Bulletin 449.

Technical service data sheets on pickling solutions. American Chemical Paint Co. Bulletin 456.

ENGINEERING • APPLICATIONS • PARTS

Carburizing Boxes. Pressed Steel Co. Bulletin 193.

Meehanite Castings. Meehanite Research Institute. Bulletin 196.

Chace manganese alloy No. 772 sheets, strips, rod and special shap described by W. M. Chace Co. Bu letin 190.

Pressed steel pots are described Bell & Gossett Co. in new Bullet 364.

Catalog gives complete specific tion data on Bunting bearings a bars. Bunting Brass & Bronze Bulletin 343.

New 32-page illustrated book contains much data on mangane steel for the railroad industr American Manganese Steel Div. B letin 388.

Illustrated leaflet presents data uses of special alloys resisting c rosion, high temperatures and ab sion. The Duraloy Co. Bulletin 3

Heat treating fixtures for pit-ty furnaces are shown in new book by Driver-Harris Co. Bulletin 36

New information sheets on taper and formed tubes have just be issued by Summerill Tubing Co. B letin 369.

54-page booklet, "File 41—Eng neering Data Sheets", gives compl facts on Ampco Metal's physic properties and service record. B letin 368.

Electrical, corrosion and heat r sisting alloys in rod, wire, ribb and strip forms. Wilbur B. Driv Co. Bulletin 192.

X-Ray Inspected Castings. Elect Alloys Co. Bulletin 197.

Steel Castings. Chicago Steel Fou dry Co. Bulletin 199.

Heat Resisting Alloys. General loys Co. Bulletin 200.

Pipes and Tubes. Michigan St Casting Co. Bulletin 201.

Bimetals and Electrical Contac H. A. Wilson Company. Bulletin 2

Cr-Ni-Mo Steels. A Finkl & So Co. Bulletin 203.

Industrial baskets, crates, trays a fixtures. Rolock, Inc. Bulletin 2

Cooper standard alloys. Coop Alloy Foundry Co. Bulletin 206.

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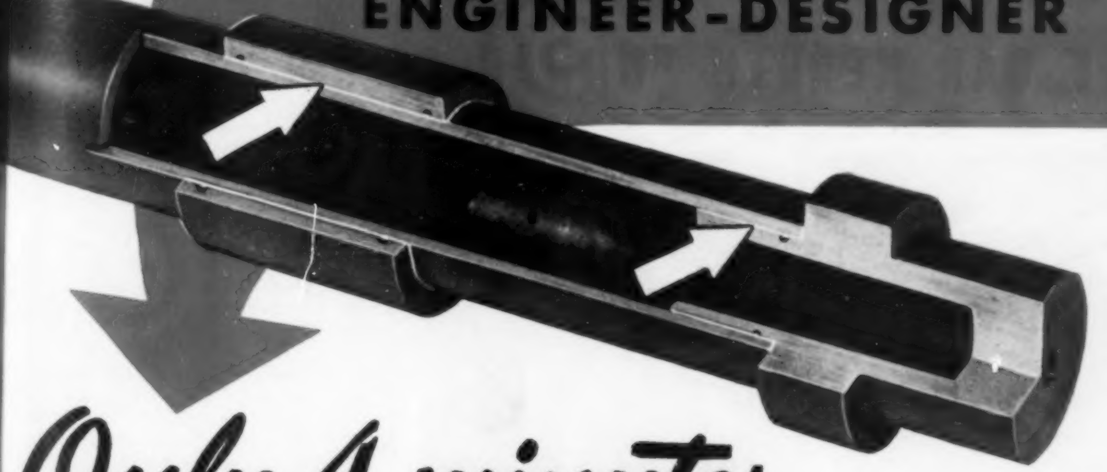
THIS *Production Short-cut* SHOULD INTEREST EVERY ENGINEER-DESIGNER



Only 4 minutes

TO BRAZE THIS AIRCRAFT GUN TURRET PART WITH EASY-FLO

The Torque Tube you see above is a good example of EASY-FLO brazed construction—a labor-metal-cost-saving construction that is replacing casting, forging and turning from the solid in the making of a wide variety of parts.

The cut-away section clearly shows this construction. An end plug and a collar are brazed to a tube with EASY-FLO. Note the small grooves, one in the plug and two in the collar. Plug and collar are assembled in position with rings of 1/16″ EASY-FLO wire **preplaced** in these grooves. Salt bath heating is used in this case, and four minutes after the assembly is immersed, out it comes, a unit equal in strength to a single piece.

The main factors which make EASY-FLO brazed construction practical are (1) the remarkable strength of EASY-FLO joints and (2) the exceptional fluidity of this silver brazing alloy which causes it to penetrate in a flash all through the joint area.

Remember EASY-FLO brazed construction when you design new parts. Also check over parts now being cast, forged or turned from the solid for opportunities of changing over to labor-metal-cost-saving EASY-FLO brazed construction.

For full EASY-FLO details write today for **BULLETIN 12-A.** Your copy will be mailed promptly on request.

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WHAT'S NEW

IN MANUFACTURERS' LITERATU

Many applications and savi through use of drop forgings shown in Drop Forging Top issued by Drop Forging Assn. letin 240.

24-pa e catalog is guide to prop ties and use of Monsanto plast Monsanto Chemical Co. Bulletin 3

Alloy Castings. Ohio Steel Foun Co. Bulletin 207.

Details of new Chemicast proc for small brass parts will be suppl by Chemicast Div., Whip-Mix Co Bulletin 330.

Reference data book entitled "T Improvement of Metals by Forgi has been issued by Steel Impro ment & Forge Co. Bulletin 409.

Illustrated leaflet describes sta less steel castings by Atlas Found Co. Bulletin 437.

Industrial applications of Natio al and Karbate carbon and graph products are illustrated in 16-pa booklet issued by National Carb Co., Inc. Bulletin 426.

Many types of heat treating a pickling baskets and containers shown in new booklet by the St wood Corp. Bulletin 445.

Complete line of Mallory rad electrical and electronic parts, w sizes, dimensions and rated cap ities is described in new 36-pa booklet. P. R. Mallory & Co., I Bulletin 448.

Interesting and informative lite ture on "Pomet" powder metallur products. Powder Metallurgy Co Bulletin 454.

Specifications and physical pro erties of bronze and aluminum allo are shown in Olds Alloys Co. Bul tin 457.

Three-color chart of decimal equi alents. John Hassall, Inc. Bullet 458.

Aluminum and aluminum all screws, bolts, nuts, rivets a washers are detailed in this 60-pa catalog. Aluminum Co. of Americ Bulletin 485.

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Modernized Bronze Bearings
● When you specify Bunting Bronze Standardized Bearings and Bars you get the product of ultra-modern methods and equipment used in the light of long experience and comprehensive research.
The exceptional physical properties inherent in the popular general purpose alloy Bunting No. 72 (SAE 660) are invariably and uniformly present. Both Bearings and Bars are completely machined and finished. Availability of these Bronze Bearings and Bars through local wholesalers is a valuable convenience to all who manufacture and service the machine tools, electric motors and the industrial machinery of all kinds for many of which these stock bearings were specified originally. Write for catalog. The Bunting Brass & Bronze Company, Toledo, Ohio... Warehouses in Principal Cities.
BUNTING
STANDARDIZED BEARINGS
Bunting
BRONZE BUSHINGS • BEARINGS • PRECISION BRONZE BARS

WHAT'S NEW
IN MANUFACTURERS' LITERATURE

"Mechanical Springs, Their Engineering and Design" is the title of a 106-page handbook just issued jointly by the divisions of Associated Spring Corporation. Bulletin 481.

8-page illustrated booklet describes crucible melting furnaces for brass, bronze, aluminum, copper and other alloys. Stroman Furnace & Engineering Co. Bulletin 473.

MELTING • CASTING • MILL OPERATIONS

Ingot Production. Gathmann Engineering Co. Bulletin 185.

Crucibles for brass, copper, aluminum and magnesium industries. Electro Refractories and Alloys Corp. Bulletin 183.

This ring-binder presents 24 pag on the use and effect of Titanium i steel and cast irons. Titanium All Mfg. Co. Bulletin 470.

52-page booklet describes Moor rapid Lectromelt furnaces for ire steel, nickel and copper melting an refining. Pittsburgh Lectromelt Fu nace Corp. Bulletin 404.

Cradle furnace which produces homogeneous gray iron of unifor chemical analysis, uniform temper ture and controlled carbon conte is described by Whiting Corp. Bu letin 357.

"Electromet Products and Service" Electro Metallurgical Co. Bulleti 186.

Interesting and helpful informa tion available on the use of allo pots for heating operation by th Swedish Crucible Steel Co. Bulleti 137.

Manganese-Titanium Steels. Tita nium Alloy Mfg. Co. Bulletin 184.

Electric Furnaces. Detroit Electri Furnace Div., Kuhlman Electric C Bulletin 189.

Operating Features, capacitie charging methods of the Herou electric furnace. American Bridg Co. Bulletin 215.

Coke oven plant construction an development in 1942 is describe and illustrated in 12-page pamphle by the Koppers Co. Bulletin 232.

"Fisher Magnesium Scrapbook" Fisher Furnace Co. Bulletin 281.

Attractive booklet describe growth, facilities and offers valuabl alloy hints. Niagara Falls Smeltin & Refining Corp. Bulletin 246.

Vertical centrifugal casting ma chine for production of ferrous an nonferrous castings is described b Centrifugal Casting Machine Co. Bulletin 315.

Interesting, descriptive leaflet o metal reclaiming mill offered b Dreisbach Engineering Corp. Bull tin 284.

"Foundryman's News Letter" is a informal and semi-technical pape for practical foundry sand test dat information on new methods an equipment. Harry W. Dietert C Bulletin 488.

GENERAL

New leaflet describes interoffic communication system offered b Executone Communication Systems Bulletin 385.

Use Handy Coupon on Page 968 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 968, 970, 972, 974, 97 976, 980, 984, 986, 988, 992, 994 and 996.